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ARTICLE No. 1.

The Food of the Mountain Barbel *Oreinus* McClelland, and its probable bearing on the introduction of Brown Trout in Himalayan Streams.[1]

By GHULAM MUSTAFA MALIK.

(*Communicated by Dr. S. L. Hora.*)

In his valuable communication 'How Trout were introduced into Kashmir', Mitchell (1931, p. 501) made the following observations about *Oreinus sinuatus* (Heckel) known as *Khont* in Kashmir:—

> 'This fish takes its name of "Sinuatus" from its habit of twisting under water when sucking alga and moss off the stones with its thick sucking lips. Thousands of *Khont* when in their best condition in late autumn used to enter the big springs of the Arrah and Achabal Rivers and remain during winter in the underground streams—the source of these springs. They are, as far as I have seen, really useful in trout water, and it was much against my wish that efforts were made to exterminate them in such streams. A gentleman from New Zealand visited Kashmir in the early days and seeing the *Oreinus* lying in black masses at the bottom of some of the pools in the Arrah River, expressed disbelief in the success of trout there with such quantities of native fish. I laughed at him and told him I knew the relative powers of both fish and that I had no doubt on the subject. I have reason to think, however, that his expressed opinion added much to the disbelief in trout prospects which then existed in the country and did harm later in causing destruction of *Oreinus* I would have saved.
>
> In some of my later reports I expressed myself strongly on the subject as the disappearance of Sinuatus synchronized with a great increase of alga and other deleterious matter as well as with a distinct decrease in the average size of trout.'

As the decrease in the local fish fauna, especially in the trout-streams, of the Kashmir Valley was brought to my notice during investigations on the indigenous species of fish used as food for trout, Dr. S. L. Hora suggested to me to make a study of the stomach contents of a large series of specimens of *Oreinus* he had obtained for systematic treatment from different parts of north-western India and Afghanistan. I have in all examined 131 specimens; 16 from Chitral, 30 from Kagan Subdivision and 85 from Afghanistan. The material, which was collected at different times of the year, has also enabled me to visualize the feeding habits of the fish during different seasons. The Chitral and Kagan specimens belong to *O. sinuatus* var. *griffithii* McClelland,

[1] Read at the Zoology Section of the 26th Session of the Indian Science Congress held at Lahore in January, 1939.

while the Helmand examples from Afghanistan represent a hitherto undescribed variety of *O. sinuatus*. Unfortunately there is very little material of *Oreinus* from Kashmir in the collection of the Zoological Survey of India, and it has not, therefore, been possible for me to dissect any specimens for the study of their gut contents. However, Mukerji (1936, p. 349), who studied the Kashmir material of *Oreinus* collected by the Yale North India Expedition, found the alimentary canal of *O. sinuatus* to be

> 'spacious long and much convoluted; it is about 4 to 5 times as long as the body excluding the caudal fin. The intestines of specimens from Kargil and Spitok were examined and found to contain lumps of gravel and mud mixed with pulpy vegetable matter. A few Chironomid larvæ were also found.'

In the case of *O. sinuatus* var. *griffithii*, Griffith (*vide* McClelland, 1842, p. 581) had observed that 'The intestines are six lengths of the body, and contain a brownish pulp. Hora (1934, p. 306) found that

> 'The alimentary canal of *O. griffithii* is greatly convoluted and is about 2·6 times the total length of the fish. As has already been observed by Griffith, it contains a brownish pulp, but in one case both the stomach and the intestine are full of sand and gravel. The structure of the lips and jaws shows that the fish adheres to smooth rocks and scrapes off algal matter which, no doubt, forms its principal food.'

It has been shown by Hora that *Oreinus* is closely allied to *Schizothorax* Heckel; in fact, the latter has been regarded only as a brook form of the former, which is generally found in lakes and large rivers with backwaters (Hora and Mukerji, 1935, p. 428). It is probable that owing to the morphological adaptations of *Oreinus* for life in swift currents it has been able to establish itself all along the southern slopes of the Himalayas (Hora, 1937, pp. 241–250) and is now a biological factor of considerable importance in the ecology of trout-streams in northern India.

Sixteen specimens of *Oreinus griffithii* from Chitral, ranging from 115 mm. to 287 mm. in total length, were examined; the majority were males, 6 being nearly ripe. In these specimens, the viscera were loaded with fat, and the alimentary canal was almost empty; a small amount of algal pulp was found in the intestine of only 5 specimens. In the remaining specimens only diatomes and algæ, with the exception of two semidigested insect remains, were found in the alimentary canal. These specimens had been collected from the Pallarga stream in July, 1929. The alimentary canal was found to be approximately 2·5 times the total length of the fish.

Of the 30 specimens of *O. griffithii* from Kagan in the Hazara District, N.W.F. Province, ranging from 110 mm. to 232 mm. in total length, the alimentary canal was greatly distended throughout and contained some blackish silt. In

7 examples, very little algal matter was mixed up with the silt; in 13 specimens silt mixed with sand, algal matter, partly digested remains of Trichopterous larvæ (Caddis worms) were found. With the exception of one mature female, all the other specimens were either males or young ones in which the gonads were not sufficiently ripe for distinguishing the sex by a superficial examination. These specimens were collected from a tributary of the Kunhar river in muddy water during April, 1938. The alimentary canal was approximately 4 times the total length of the fish.

From the Helmand river I examined 85 specimens, ranging from 115 mm. to 228 mm. in total length. The alimentary canal was found to contain algal matter, sand grains and pebbles, and remains of Trichopterous larvæ and beetles. Besides algal pulp, two different types of algal filaments—stiff, thick, hair-like, black filaments radiating from a central base in all directions and soft filaments forming a bunch, were found among the stomach contents. In 12 mature males and 2 females, the alimentary canal was almost empty, only containing a very small quantity of algal pulp. Their livers appeared to be somewhat larger and the viscera were loaded with fat. The alimentary canal varied from 3 to 3·4 times the total length of the fish. These specimens had been collected from the Helmand river at Girdun Dewar during December, 1937.

From the above analysis of the gut contents of 131 specimens of *Oreinus* and the previous observations on the subject the following facts can be adduced:—

(i) *Oreinus* feeds on slimy vegetable matter that is often found encrusting rocks and stones in rapid waters. As such growths are invariably inhabited by insects of various kinds, they are also swallowed with the algæ. Further, if mud or sand is settled on the rocks, as was presumably the case in the tributary of the Kunhar river in the Kagan Subdivision, it is also scraped and ingested. Trichopterous larvæ often form their tubes on rocks and there is evidence that such larvæ are also devoured along with the vegetable matter.

On the whole, it may be stated that the fish is a bottom-feeding vegetarian, and any animal matter found in its intestine is probably only accidental.

(ii) During the breeding season the ripe males and females probably give up feeding and depend for nourishment on the fat stored in the viscera.

(iii) The proportion between the length of the alimentary canal and the total length of the fish is partly dependent on the quantity of matter in the alimentary canal.

(iv) The relative length and form of the alimentary canal show that large quantities of food have to be ingested to derive sufficient nourishment for the fish.

The conclusion that the principal food of *Oreinus* consists of algæ is further borne out by Mitchell's observations that the disappearance of *O. sinuatus* from Kashmir waters synchronized with a great increase of algæ and other deleterious matter in the streams.

We may now consider the biological effect of the presence of *Oreinus* in the trout-streams of Kashmir. There are two species of trout that have been introduced in the valley, the Brown Trout, *Salmo trutta fario*, and the Rainbow Trout, *Salmo* (*Oncorhynchus*) *irideus*. The former is, in the main, a carnivorous fish and it is only by accident that it ingests vegetable matter. Hamid Khan's recent studies (1938, p. 430) on the natural food of the Brown Trout in the Kulu Valley support the earlier observations of Mitchell and Howell and show that it feeds mostly on the bottom-living animals even under Indian conditions. Fifty per cent. of the fish were found by Hamid Khan to feed on fish fry in August, and this no doubt is due to the abundance of fish fry in the streams at this period as most of the Hill-stream fishes, especially mountain Barbels, breed during the rains. On this point Howell (1916, p. 318) noted that in Beas river *Oreinus* 'undoubtedly form and will form one of the staple foods of our *Salmo fario*' and, in view of their great fecundity, anticipated no danger of these indigenous fish being exterminated.

So far as the Brown Trout is concerned it is thus advantageous to cultivate *Oreinus* in the streams for two reasons, (i) to keep the streams clean of vegetable growth and of deleterious matter, and (ii) to provide food for the Trout. The absence of too much vegetable growth in the streams enables large colonies of rock-inhabiting insect larvæ and other animals to grow and thus form the natural food of the Brown Trout. It is interesting to note that according to Mitchell there was a distinct decrease in the average size of the trout when *Oreinus* were artificially exterminated from the trout-streams of the Kashmir Valley.

No details are available of the feeding habits of the Rainbow Trout in the Himalayan streams. In the Kashmir hatcheries however, they are fed on local species of fish and evidently flourish very well on this diet. Unless data are collected regarding the natural food of this species in the Himalayan streams, it is difficult to judge the effects of its introduction on the local fauna.

From the above it would seem desirable to investigate the local fauna and flora of a stream before introducing trout of any kind into it, as any exotic species is certainly liable to upset the balance of nature established after centuries of existence among the various inhabitants of a stream. In streams where they have been introduced already it is best to study the new ecological balance, if any, that may have been established. In this con-

nection it is pertinent to recall the observations of Mosley (1926), who, while commenting on Tillyard's (1921) report on the effect of introduction of trout on the native insect-fauna in New Zealand, noted that

> 'Now-a-days trouts are being introduced everywhere and perhaps we are deluded by the immediate success of our efforts. The history of New Zealand waters warns us that we must look beyond the immediate future, and that stocking should be carried out on a very moderate scale, while sanctuaries for trout-insect-food should be established in all areas where trout are being introduced. Crustacea or mollusca should be imported, if not already present, to offer an alternative diet to the fish. Otherwise, the trout may thrive lustily in the virgin waters, increase abundantly, and by reason of their well being doom themselves to inevitable destruction.'

In New Zealand there are practically no freshwater fishes of commercial importance to guard against, but in this country our rivers and streams are full of valuable species. It is of the highest importance, therefore, that a thorough biological investigation of a stream should precede the introduction of trout, especially of the Rainbow Trout.

I wish to express here my grateful thanks to Dr. B. Prashad, Director, Zoological Survey of India, for the facilities to work in his department and for his valuable help. To Dr. S. L. Hora I am greatly indebted for the material, literature, guidance and constant supervision in the course of this work.

Summary.

Attention is directed to Mitchell's observations regarding the destruction of the Mountain Barbels of the genus *Oreinus* from the Kashmir trout-streams in relation to the growth of Brown Trout. The feeding habits and food of *Oreinus* are described and an analysis of the gut contents of 131 specimens of *Oreinus* from Chitral, Kagan Subdivision of the Hazara District, and Afghanistan is given. It is concluded that Brown Trout, a carnivorous fish, flourishes well in association with *Oreinus*, as the latter keeps the streams clean of the vegetable growth and other deleterious matter and thereby encourages the growth of insect larvæ that inhabit rocks and stones and form the food of Brown Trout. Further, its fry provides food for the trout during the season when insects, which form its normal diet, are scarce.

No definite data are available about the food of Rainbow Trout in Himalayan waters, and it is therefore difficult to assess its influence on the indigenous fish-fauna of the streams of this area.

In view of the above a plea is made for a thorough biological investigation of the local waters before any exotic species is introduced.

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ARTICLE No. 2.

Cases of Mortality of Brown Trout, *Salmo trutta fario* Linn., in the Hatcheries of the Hazara District, N.W.F. Province.

By GHULAM MUSTAFA MALIK.

(*Communicated by Dr. S. L. Hora.*)

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INTRODUCTION.

During the last 13 years, the Zoological Survey of India received information from the Forest Department, N.W.F. Province, regarding several cases of mortality among the stock of Brown Trout kept in the hatcheries in the Hazara District. Though the results of *post mortem* examinations of the specimens sent, with notes on the probable cause of death in each case, were duly communicated to the authorities concerned, the material had not been studied in detail so far. During the period of my training in the Zoological Survey of India, Rai Bahadur Dr. S. L. Hora very kindly placed this valuable material and the relevant papers at my disposal and suggested that I should prepare a detailed report on the mortality of the Brown Trout in the Hazara District. I am grateful to Dr. Hora for his kindness in this matter and for his helpful suggestions in the preparation of the report. I am also indebted to Dr. B. Prashad, Director, Zoological Survey of India, for facilities for work in his department and for helping me with literature in foreign languages.

From 1926 to 1929 all the enquiries were received from the Jabori Hatchery through Mr. Balwant Singh, Divisional Forest

Officer, Siran Forest Division. No enquiries were received from 1930 to 1935, but from 1936 several enquiries have been received from the Shinu Hatchery through the Divisional Forest Officer, Kagan Forest Division. The latter has also supplied details about the Shinu Hatchery. The stock of fish for both the hatcheries was obtained as ova from Kashmir though later local ova were produced. As the probable causes of mortality in the two hatcheries are different, it is necessary to deal with the two sets of specimens separately.

Mortality of Brown Trout in the Jabori Hatchery.

On an enquiry being made about the precise location of the Jabori Hatchery, the Divisional Forest Officer, Kagan Division, has written to say that 'the Jabori Hatchery was washed away by floods several years ago and has since been abandoned. It was situated on the Siran river at an elevation of about 4,500 ft. The valley is adjacent to that of Kagan and the crow flight distance between the two hatcheries was about 20 miles'. The fish were stocked in pucka masonry tanks (40′×10′×5′), which were partly roofed over. The water supply was from a *nallah* (rivulet) whose temperature in winter months went down to 40°F. and in exceptional cases to 35°F. In the area it snows twice or thrice a year while hailstorms are a common occurrence. The cases of mortality in this hatchery were due either to the growth of algæ on the gills or to the development of thyroid tumours.

Growth of Algæ on gills.—In his letter dated the 25th January, 1926, Mr. Balwant Singh intimated that 'Owing to a certain disease, which manifests itself in the form of a swelling on the neck the fish stops food for 3–5 days and then dies'. The specimen sent under cover of this letter was, on examination, found with its gills thickly covered with a growth of filamentous algæ. This growth was so thick that it is likely to have interfered with the respiration of the fish and caused its death through 'suffocation'. In attributing the death of the fish to asphyxiation, Dr. Hora enquired from Mr. Balwant Singh whether he had noticed that 'before death the fish must have been restless coming oftener to the surface or to the edge of the pond gasping for breath?'. To this he replied that the statement 'is too true and seems to be probable reason of the mortality'.

The specimen was sent to Prof. P. Brühl of the Calcutta University who, after an examination of the algæ on the gills of the trout, reported that the material was not properly preserved for identification.

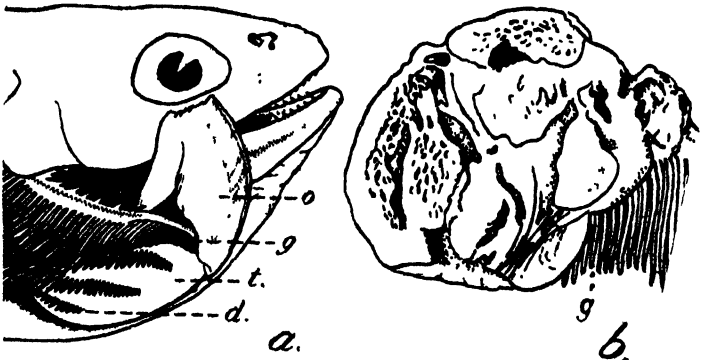
Mortality of fish due to an abundant growth of algæ in a pond is rather an unusual occurrence, but by no means unknown. For eradicating excess of algæ from trout-ponds a dose of one part of copper sulphate per million parts of water gives good

results and this strength has experimentally been shown to have no deleterious effects on fishes.

It may, however, be noted that

> 'Unless unduly abundant, algæ have a beneficial effect, and their growth should be encouraged. There are no more efficient agents in keeping the ponds in a sanitary condition than the algæ and associated organisms. Not only do they aid in aerating the water and keeping it free from objectionable substances, but it is found that trout feed on them to a considerable extent, and they, no doubt, perform much the same function in the trout's metabolism as do vegetables in the human diet.'—(Davis, 1937, p. 12.)

Thyroid Tumour or Goitre.—On the 10th November, 1928, Mr. Balwant Singh sent a specimen of trout which had died in



Thyroid tumours in Brown Trout.

(*a*) The head of a Brown Trout from the Jabori Hatchery suffering from goitre. The specimen also shows degenerate gill-filaments. *Nat. Size.*

(*b*) Transverse section of one of the thyroid tumours showing malignant growth. *Nat. Size.*

d. Degenerate gill-filaments; *g.* Normal gill-filaments; *o.* Operculum; *t.* Thyroid tumour.

the breeding stock at the Jabori Hatchery with a note that 'There was a boil noticeable on the neck of the fish when it was found dead'. The specimen reached Calcutta in a desiccated and badly preserved condition, but Dr. B. Prashad found big tumour-like growths on both sides of the neck. Unfortunately this specimen cannot now be found in the collection of the Zoological Survey of India and may have been thrown away owing to its poor state of preservation. On the 9th January, 1929, Mr. Singh observed that the mortality in the stock fish was still on the increase. He further stated that 'The tumour first appears on the neck and swells till it goes into the throat. The fish does not eat a few days before death and lies quietly at the bottom of the tank. I had operated a few of the fish

but they have also died'. Under instructions from Mr. Singh the Forest Ranger at Jabori sent to the Zoological Survey of India two dead fish for *post mortem* examination. Both the specimens show well-marked tumorous growths of the thyroid glands. In the larger specimen (plate 1, fig. 1), 75 mm. in head length, the tumours are present between the 1st and 2nd, 2nd and 3rd, and 3rd and 4th gill arches on the left side. Ventrally the tumours have coalesced and lifted the gill-covers outwards. Dorsally they project into the cavity of the pharynx as two small nodules (plate 1, fig. 2*a*). In the other specimen (plate 1, fig. 3), 51 mm. in head length, the tumour on the left side is larger than the one on the right side. On both sides the tumours have affected the areas between the 2nd to the 5th gill-arches. Though these growths are well-marked ventrally, dorsally they have not affected the floor of the pharynx. In both the specimens the gill-filaments have degenerated in the affected parts (text-fig. *a*). Internally the tumours are filled with branching structures which extend into the neighbouring tissues and show a marked resemblance to some malignant growth (text-fig. *b*).

Thyroid tumours are rarely known in wild fish but occur fairly frequently in fish kept under artificial conditions. Several cases of this disease have been recorded among trout from the United States, Europe and New Zealand. From India Dr. Hamid Khan Bhatti (1939, p. 654) has recorded occasional cases from the Kulu Hatcheries where the disease has, however, never occurred in an epidemic form. In the Jabori Hatchery, however, the enlargement of the thyroid glands seems to have become an epidemic which resulted in great losses to the stock.

> 'The primary cause of thyroid tumour is now generally conceded to be a deficiency of iodine, which is essential to the proper functioning of the thyroid gland. There is also evidence that overcrowding, overfeeding, a limited water supply, and insanitary conditions in the ponds are important contributing factors.'—(Davis, 1937, p. 68.)

From the observations recorded above it may safely be inferred that in the Jabori Hatchery there must have been an abundant growth of algæ. It is further known that algæ absorb a considerable quantity of the iodine dissolved in water. The appearance of thyroid tumours in the trout at the Jabori Hatchery can thus be definitely correlated with the lack of iodine in the water supply and its insanitary conditions. Administration of iodine in one form or another is known to cure this disease. According to Davis (*loc. cit.*)

> 'At the Bureau's hatcheries very good results have been obtained with the so-called Lugol's solution, which consists of 1 percent iodine dissolved in a 1-percent solution of potassium iodide. A tablespoonful of this solution thoroughly mixed with about 50 pounds of ground food is sufficient to keep the fish from showing any trace of thyroid tumor.'

From the sizes of the specimens, head lengths 75 mm. and 51 mm., it seems that the specimens were probably 3 and 2

years old respectively. Earlier workers on this disease have shown that the disease is most active during this age and that a greater number of goitres appears during the 2nd and 3rd years of trout's growth, when the thyroid is probably most active (Davis, 1937, p. 68). It may be of interest to record that the people living in the Siran Valley also suffer from goitre which shows that the waters of this valley are certainly deficient in iodine.

Mortality of Brown Trout in the Shinu Hatchery.

According to the information supplied by the Divisional Forest Officer, Kagan Division, the Shinu Hatchery is situated at an elevation of 8,000–9,000 feet, and is subject to snow falls. Though it is extremely cold in winter, the summers are fairly hot. There are no shade trees in the vicinity of the Hatchery, though a dense forest of deodar and blue pine clothes the valley. The annual rainfall is 3·7 inches.

The fish ponds are cemented and half-roofed over with wooden planks and with wire guaze covers over the other half. The source of water is a spring, but the supply falls short in summer and is supplemented from a neighbouring stream. The water is clean with a temperature of 54°F. in summer and 48°F. in winter. It is reported that the people, who use this water, although poorly fed, keep excellent health. It is perhaps for this reason that the fish in this hatchery do not suffer from goitre, as was the case in the Jabori Hatchery. The ponds are cleaned twice a week and the sick fish are kept in separate ponds.

The fish are fed twice a day; wheat flour is given on 4 days of the week and minced mutton for the remaining 3 days. Each adult fish is fed on an average of one *chatak* of diet a day. The fish used to be given salt baths by placing a lump of salt at the intake, but at the suggestion of the Game Warden, Jammu and Kashmir State, the practice has been discontinued. It is reported that, as a rule, the fish in this hatchery appear indifferent to food and look out of sorts.

As a result of a careful examination of the seven specimens received from this hatchery it seems probable that death was due either to malstripping, malnutrition, or visceral abnormalities.

Malstripping.—A specimen, 195 mm. in standard length, was received on the 24th February, 1937, without any note as to the circumstances of its death. *Post mortem* examination showed that the abdominal cavity was filled with ova and the alimentary canal was empty. The caudal fin was damaged and parts of the body were covered with a copious secretion of slime.

The presence of about half the normal number of eggs in the abdominal cavity shows that stripping has not removed all the ova and that the fish may have later, instinctively, used the

caudal fin against the bottom of the pen for shedding the remaining eggs. The unnatural and artificial conditions of the pen presumably inhibited the normal spawning of the fish and resulted in its exhaustion and subsequent death.

Another fish, stated to be 3 years old and measuring 192 mm. in standard length, was received on the 9th April, 1937; it showed almost the same symptoms as noted in the above case. The body cavity contained a large number of loose ova, which were presumably not discharged when the fish was stripped.

The 3rd specimen showing evidence of malstripping was received on the 16th May, 1938. It was a 4 years old fish, measuring 237 mm. in standard length. I carried out the *post mortem* examination of this fish and found that the ovarian membrane was injured, the viscera were packed with loose ova and their shells, and a few ova were present even behind the liver. About 3 dozen eggs were still intact with ovarian follicles at the anterior end of the ovary. It was also noticed that some of the ova and their crumbled shells had conglomerated together near the vent and had blocked its passage. The peritoneum was also injured and the last portion of the intestinal mesentery was found to be ruptured a little above the vent. The stomach and intestine were empty.

I am of opinion that the injuries referred to above had been inflicted during the process of stripping. The mere presence of so many eggs and crumpled shells shows that this fish had been badly manipulated, and undue pressure had been applied over the abdomen during the process of stripping. This is also clear from the fact that a mass of ova had conglomerated near the vent and blocked its passage, and that the last portion of the intestine was free of any fæcal matter. Further, the presence of eggs in the ovarian follicles shows that all the eggs had not yet been discharged in the body cavity and the fish was, therefore, not fully ripe for artificial manipulation.

Cases of malstripping are generally due to carelessness on the part of inexperienced persons, who are further not able to judge whether a fish is ripe for artificial manipulation or not. It is difficult to lay down any general rule for proper stripping but the following points may prove helpful.

Conditions favourable for stripping.—Males mature at an earlier age and fully matured males usually shed milt when they are caught for manipulation. Sometimes the presence of eggs at the bottom of the trough may induce ripe males to shed their milt. When artificially stripping care should be taken to have young males (over 6 to 7 years old males are not of much use), and that they should be sufficiently ripe to yield milt on stripping.

A ripe female of artificially reared stock is characterized by its distended, flabby abdomen. The abdominal wall is so stretched that it becomes sufficiently thin for the ova to be felt by an expert by mere touch. At full maturity the ova lie loose

in the abdominal cavity so that by holding the fish with the head downward the ova travel towards the head while by reversing the position of the fish the ova travel towards the vent, and the part of fish harbouring ova becomes distended. Under favourable conditions, a ripe female will often shed its ova voluntarily, but may be helped by slowly moving its tail to and fro, and finally by a slight manipulation of the abdomen from the pectorals towards the vent. The ova are to be collected first towards the vent and then stripped out without pressure by means of right thumb and forefinger in a way that the abdomen of the fish is held between the thumb and the fingers. The thumb is then moved rapidly up and down without force in such a way that it always follows the eggs and never goes in front of them. The whole operation should not take much time otherwise the fish, which is held out of water, is likely to suffer.

During the spawning season the ripe fish will be seen jumping up the pond and trying to get out. Under such circumstances a few eggs may even be seen lying at the bottom of the pen or the shallow spawning ditch generally at the head of the pen.

Attention may here be directed to the fact that the observations regarding the movement of eggs and the flabby condition of the abdominal region of ripe females recorded above are not in conformity with the views recently expressed by Percival (1937, p. 346) as a result of his investigations on the stock of Brown Trout in the Ellesmere Lake, New Zealand. In all probability the differences in the results are due to the fact that Percival dealt with a wild stock, while the observations recorded here deal with stock reared under artificial conditions. My observations are, however, in agreement with those of Stockell (1936, pp. 80–96) and Atkins (1900, p. 35).

As an explanation of these differences, it may be stated that in the wild state the trout usually take a number of days to spawn as compared to a few minutes of artificial spawning. In the former case, in the evacuated portions the abdominal wall thickens and resumes more or less normal shape by the time all the eggs are discharged. Accordingly, at no stage the abdomen looks flabby. Although the fish may spawn several times in the wild state, in artificially reared stocks it is not desirable to subject them to stripping more than once (*vide* Kendell, 1922, p. 206). For stripping it is imperative to extrude all the eggs in one operation, and it is essential, therefore, to ascertain, in the first instance, that all the eggs have been discharged into the body cavity and are fully ripe. The discharging of all the eggs into the body cavity takes some time, but is always fairly rapid. Many fish sometimes hold their spawn back owing to alarm, excitement or unfavourable weather conditions, even when they are fully ripe. Such fish should never be stripped at that time, but left aside for one or two hours till normal or favourable

conditions are restored. As a general rule, a fish should be spawned only when it has a will to spawn.

Malnutrition.—In this section I discuss certain cases in which, as judged from the stomach contents and the gross anatomy of the alimentary canal, death can only be ascribed to overfeeding.

A specimen of trout, about 245 mm. in standard length, was received on the 7th of December, 1938, with a note that the fish jumped upwards, probably at the time of feeding, and struck against the wooden planks that are used to cover one-half of the tank. This resulted in instantaneous death and when picked up blood was noticed coming out through its mouth.

Post mortem examination of the fish showed that it was a female with well developed ova that had not yet been discharged from the ovarian follicles into the body cavity. The greater part of the body cavity was, however, filled with ovaries. The stomach and gullet contained a large solid piece of raw, undigested meat. In consequence the stomach was enormously distended and its walls had become thin and almost papery, and showed no evidence of their characteristic corrugated nature.

From the above it would seem probable that the lump of meat lodged in the stomach and gullet was too large for the fish as it had distended the stomach to such an extent as to obliterate the grooves and folds of the mucosa.[1] Presumably, being unable to relieve itself by vomiting out the lump of meat the fish seems to have jumped up in a fit of great discomfort and thus struck itself against the wooden planks. The force of this impact can be judged from the fact that the fish died instantaneously and started bleeding through the mouth.

It is quite unusual that a fish, with its body cavity almost filled with ovaries and on the verge of spawning, should swallow such a big lump of food, as normally spawning fish, especially females, either abstain entirely or take very little food.

The second specimen showing evidence of malnutrition is about 300 mm. in standard length. It was received on the 24th of August 1938 with a note that it was a 4 years old trout which fell ill on the 1st of August 1938, and died the next day. During the period of illness it did not take anything but remained in the water with its tail pointing upwards. It was given salt and clay bath but without any effect. The weather was dry and the temperature of the water was 54°F.

External examination showed the head in the regions of the articulation of the jaws bulged outwards on either side.

[1] Blake (1930, p. 45) and Green (1913, p. 78) have described much distended stomachs of sea bass, and indicated that when the stomach is excessively filled, the mucosa looses all folds, the walls become very thin, pliable and quite red.

Post mortem examination showed that, though the stomach was empty, it was greatly distended and papery. The lower portion of the intestine contained a small quantity of undigested, partially ground, wheat grains. The gullet was also considerably distended and could hardly be distinguished from the stomach.

A consideration of the above data leads one to the conclusion that the fish had presumably swallowed large quantities of food. This is not only clear from the condition of the stomach and the gullet, but also from the fact that at least some of the food, that had passed into the intestine, had not been acted upon by the gastric juices presumably owing to the distended nature of the stomach. During the period that this lump of food remained in the stomach the fish must have been greatly inconvenienced, but it seems that ultimately the fish had vomited out the food. In this effort the fish may have felt exhausted and ultimately died. The abnormal bulging outwards of the jaws at their articulations (plate 1, fig. 4) also shows that the mouth opening must have been greatly extended for ejecting the large lump of food.

Attention may here be directed to an abnormal Brown Trout from the Kagan Valley reported by Mukerji (1936). The specimen was sent by the Divisional Forest Officer, Kagan Forest Division, in January 1936, for *post mortem* examination and report. Mukerji found that the stomach of the specimen had become everted into the pharyngeal cavity. In a note at the end of his article, Dr. S. L. Hora stated that 'under certain unhealthy conditions the fish are capable of ejecting through the mouth the contents of the stomach. It is possible that sometimes this action may be so violent that the stomach may become everted into the cavity of the mouth'. In view of what is stated above it seems more probable now that the abnormality reported by Mukerji may have been caused by the violent vomitting action of the stomach consequent upon overfeeding by the fish.

To avoid such occurrences it would seem desirable not to give the fish their entire ration of the day at one time, but to feed them on smaller quantities at a time and, in consequence to feed them twice during the day. Great care should also be taken that the fish are not fed on unduly large lumps of food. The present practice of feeding the fish on exclusively vegetarian diet for 4 days and meat diet for three days may also have a bearing on the overfeeding by the fish.

The exclusively vegetarian diet, being rather unnatural for Brown Trout, cannot easily be assimilated by the fish. According to Davis (1937, p. 20) trout are unable to digest raw starches though there is evidence that to some extent they can assimilate cooked starches just as well as proteins and mineral salts. It seems, therefore, quite probable that the fish have suffered from

a sort of partial starvation through lack of proper quality of food.[1]

It would be advantageous, therefore, to give a mixed diet at every meal. Leach (1919, p. 10) recommends that food may consist of almost of any kind of fresh wholesome meat mixed with shorts or a low grade flour. The advantage of such a combination is that the flour, on being mixed with meat, etc., absorbs meat juice and thus saves waste by solution. Instead of wheat flour any other flour of cereals or beans can be substituted with advantage. Such flour, should, however, be cooked thoroughly before mixing with meat as cooking increases the digestibility and improves the consistency of these vegetable products (*vide* Davis, 1937, p. 20). From the collections of indigenous fish received by the Zoological Survey of India from the Kagan Valley it is clear that mountain Barbels of the genus Oreinus are found in abundance there. It will, therefore, be of great advantage to feed the trout on fish diet also, especially on *Oreinus sinuatus* Heckel, which is one of the commonest and widely spread Barbel of the area.

Visceral abnormalities.—In this section is described a highly abnormal case of visceral adhesions, which is perhaps the first of its kind to be noted among fishes. The specimen under report is stated to be a 4 years old trout and is 325 mm. in standard length. It was received on the 18th of October, 1938, with a note that it fell ill on 8th October at 6 P.M. and remained in a reverted position in the tank with 4 feet depth of water. During illness it did not take any food and regular bleeding was observed from its mouth. It died on the noon of 10th October, 1938. The temperature of the water in the tank was 54–56°F. The fish was fed on wheat flour. An external examination showed that it was quite thin and emaciated, its height being contained $4\frac{1}{2}$ times in the standard length (plate 1, fig. 6). The eyes were opaque and somewhat depressed.

Post mortem examination revealed extensive adhesions of the alimentary canal to the body wall. The pyloric end of the stomach, including a portion of duodenum, had formed strong adhesions with the abdominal wall (plate 1, fig. 5). The posterior portion of the intestine, measuring 73 mm. in length, had also adhered to the dorsal wall of the abdomen. A sort of fibrosis was noticed at the adhered portions. The pyloric portion is so much thickened and constricted that hardly any

[1] In this connection certain observations on the feeding of trout in Kashmir may be recalled. It was a practice to feed trout on very small quantities a number of times in a day in order to raise them for exhibition to visitors, besides their usual daily meal at 5 P.M. Later their feeding was restricted to once a day only at 5 P.M., with the result that the hungry trout usually swallowed large quantities of food which resulted in many deaths overnight. Their stomachs were also found to be abnormally distended.

lumen can be traced towards the intestine, the alimentary canal was quite empty. The kidneys and the liver were very black in colour, and the liver was very much shrunken and reduced in size.

From our knowledge of the human cases, formation of such adhesions can be attributed to the following two main causes:— (1) Ulceration of the gut and subsequent formation of a fistula or an aperture resulting in the inflammation of the adjacent parts and peritoneum. Such ulceration may result from a mechanical injury through the swallowing of a bone or some other irritating hard substance. In the present specimen no ulceration or puncture of the intestine was noticed nor there can be any possibility for this cause, as the fish are fed on controlled diet. (2) Direct injury to the peritoneum of the abdominal wall. Any injury inflicted to the peritoneum will cause inflammation and its subsequent union with the intestine by the growth of connective tissue. The specimen under report is a spent female that died on the 8th of October, 1938. The Brown Trout generally commences breeding in October and it would, therefore, seem probable that during stripping undue pressure had been applied over the abdominal region, which may have resulted in an injury to the peritoneum. Inflammation thus set up may later have caused the adhesions noted above. Such adhesions must have interfered with the peristaltic movements of the intestine, and finally effected the feeding of the fish. This is confirmed by the empty alimentary canal and the emaciated condition of the fish.

Conclusion.—To sum up it may be noted that the causes of mortality in the Shinu Hatchery, so far as they can be judged from the available material, are such that some of the deaths, at any rate, can be prevented by the employment of better trained staff for manipulation during stripping and by feeding the fish on a suitable mixture of meat and vegetable diet at least twice a day.

SUMMARY.

From an examination of the material in the collection of the Zoological Survey of India, the cases of mortality of the Brown Trout in the Jabori and Shinu Hatcheries of the Hazara District, N.W.F. Province, are discussed. Short descriptions of the two hatcheries and the results of *post mortem* examinations of the various cases are given.

In the case of the trout in the Jabori Hatchery the mortality is traced to excessive growth of algæ and to the development of thyroid tumours or goitre. The death of trout in the Shinu Hatchery is attributed to malstripping and malnutrition. An interesting case of visceral abnormality is also described. Remedial measures are suggested, and in the case of trout in the Shinu Hatchery, it is concluded that some of the deaths at least could be prevented by the employment of better trained staff for manipulation during stripping and by feeding the fish on a suitable diet.

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Explanation of Plate 1.

Fig. 1.—The head and anterior part of the body of *Salmo trutta fario* Linn. showing enlargement of thyroid glands (*vide* p. 10).

Fig. 2.—Same as above. Dissected to show the inward growth of the thyroid glands which are represented by two small nodules (*a*) at the floor of the pharyngeal cavity (*vide* p. 10).

Fig. 3.—Lateral view of the head and anterior part of the body of *Salmo trutta fario* showing enlargement of thyroid gland (*vide* p. 10).

Fig. 4.—Ventral view of the head and anterior part of the body of a Brown Trout showing abnormal bulging outwards of the jaws at their articulations (*vide* p. 15).

Fig. 5.—A portion of the Brown Trout from the Shinu Hatchery (dissected) showing visceral abnormality (*vide* p. 16).

(*a*) Adhesion of the pyloric end of the stomach with the body wall on the left; (*b*) adhesion of a portion of the stomach with the body wall on the right; (*c*) portion of the intestine adhering to the body wall.

Fig. 6.—Lateral view of the Brown Trout from the Shinu Hatchery suffering from visceral abnormality (*vide* p. 16).



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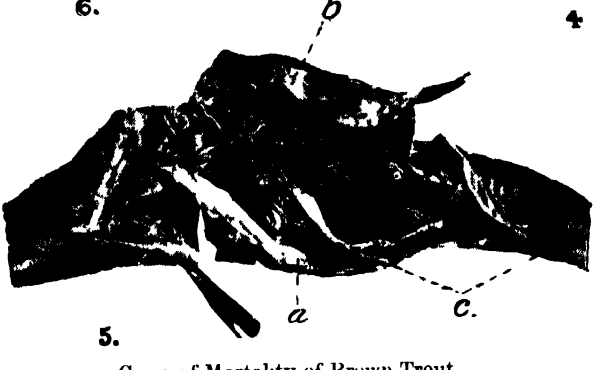
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Cases of Mortality of Brown Trout.

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ARTICLE No. 3.

Studies on the Endemic Flora of India and Burma.

By D. CHATTERJEE.

(*Communicated by Dr. K. Biswas.*)

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INTRODUCTION

The present work was undertaken at the suggestion of Professor Sir William Wright Smith in October 1937, for the Ph.D. degree of Edinburgh University. No recent detailed and complete analysis of the Indian and Burmese floras from the point of view of their endemic contents has been undertaken by workers on Botany; those who have attempted partial research in this direction have produced data of too fragmentary a nature to permit of a general view upon the subject. In the past Sir J. D. Hooker, in his Introductory Essays to the Flora Indica (1855), and subsequently in that section of the Imperial Gazetteer of India (1904), which is given to Botany, divided the Indian Empire into several Phyto-geographical regions. His knowledge of the Indian flora was profound and his division of the area was, and still is, very satisfactory. C. B. Clarke in

Journ. Linn. Soc., XXXIV, (1898), attempted a somewhat different classification of the Indian Floral regions on a more statistical basis, following the distribution of Cyperaceæ in India. H. G. Champion, in a recent publication (Indian Forest Record, 1936), has endeavoured to indicate the general vegetational types of the country from the different viewpoint of climatic relations. Taking all these works into consideration, in the present paper I have outlined a modified method of dividing the Indian area. I do not claim that my principles of division are final, nor is it to be expected that unanimity of opinion is to be secured on the subject, when the vast area of the country with its much diversified vegetation presents so many problems and difficulties of so varied a nature.

Since the publication of the first volume of Hooker's Flora of British India in 1872, about seventy years ago, constant additions of new species and of new records of known species have been made to the flora of the country. Species of earlier botanists have been broken into several smaller specific units and many have been reduced or interpreted differently in later monographs. These records have been published in hundreds of different journals of many countries and to-day there is no single publication containing an up-to-date list of Indian Plants; and so, as a preliminary to further study it was decided to make a complete list of Indian species showing their present distribution. It might be expected that in drawing up a list of this kind,[1] where an accurate record of the identity and distribution of each species is an absolute necessity, difficulties of various kinds would be encountered. Thus the question of whether a particular plant is endemic in India or not, can only be settled by looking up all available records of the countries that surround India. Hundreds of species and scores of genera which seemed endemic in Hooker's time have now been found widely distributed in Siam, Malaya and the Philippines, so that they can no longer be reckoned as endemic in India. Consequently it has been necessary completely to revise the records of distribution published in the Flora of British India and other periodicals. All accounts of recent collections on the Burma-Yunnan and Burma-Tibet frontiers and in the Tibetan-Himalayan regions have been consulted, as well as 'Flora siamensis enumeratio' by Craib

[1] The list or catalogue shows the distribution of Indian Dicotyledons in different phyto-geographical areas, and outside India in the surrounding countries (when they occur). The families and genera have been arranged as in the Flora of British India of Hooker and the species are arranged alphabetically. The catalogue has been carefully compiled and incorporates all new species described till the end of 1935. Modern nomenclature has been followed and used as far as practicable and every available publication has been consulted for this compilation, though absolute accuracy is not claimed. It has been also necessary to make a large number of new combinations.

and 'Symbolæ Sinicæ' by Handel-Mazzetti, all of which have helped to throw much light upon the Indo-Chinese floristic elements in the Indian area.

At the same time genera and species which occur just outside the boundaries of India proper as well as many in Malaya, Sumatra, Java, and Ceylon have had to be excluded, though they may have been recorded in the Flora of British India. None the less, the great influence of these countries upon the flora of India is evident although the vegetation of most of these regions is very different from that of India;—for example, Ceylon, though so close to India, contains a high percentage of endemics of its own.

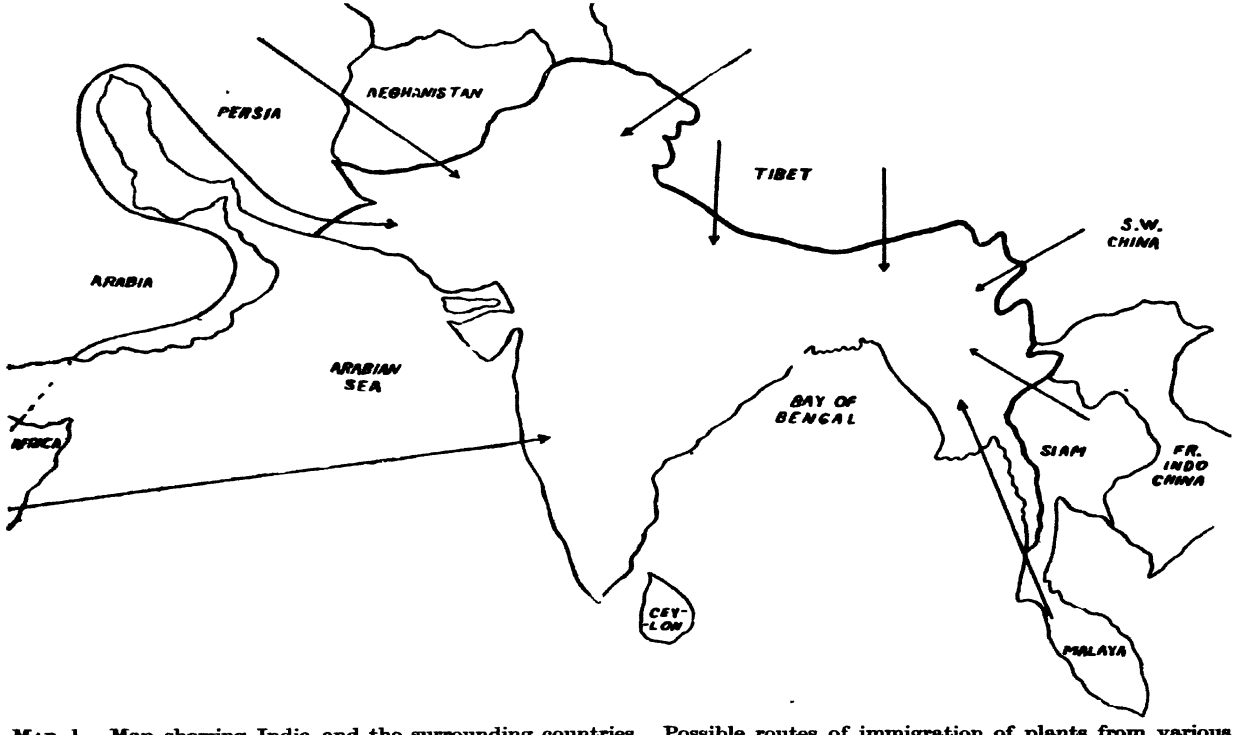
In making a list of species for the catalogue I have had to restrict myself to Dicotyledons which in themselves form a vast assemblage. Having completed the catalogue, and using the information it afforded, I have endeavoured to draw up in some detail an account of the endemic elements in the Indian flora and an estimate of the influence of the different floras of the surrounding countries upon that of India, by a study of those genera and species which seem to furnish significant data.

India and the surrounding countries

The surrounding countries which have contributed to the Indian flora (shown in the catalogue under column 'Outside India') are, Ceylon, Burma, Malaya (with Sumatra, Java, Borneo, and the Philippines), South-West China (which is taken to include the western provinces of China with Siam and French Indo-China), Tibet, Eastern China and Japan, Western Asia (including Afghanistan, Persia, Arabia and eastern part of Mediterranean region) and finally Africa (with Madagascar). A large number of species have come to India from these surrounding countries. From them certain families can be readily marked out as supplying many introductions to India—e.g. the majority of the *Cruciferæ* and *Caryophyllaceæ* from the Mediterranean region; *Dipterocarpaceæ* and probably *Ternstroemiaceæ* from Malayasia; *Papaveraceæ* and *Fumariaceæ* from North Asia; while the majority of *Capparidaceæ* and *Ancistrocladaceæ* suggest an influx from Africa. The following map of S.E. Asia shows the probable routes of immigrants. (Map No. 1.)

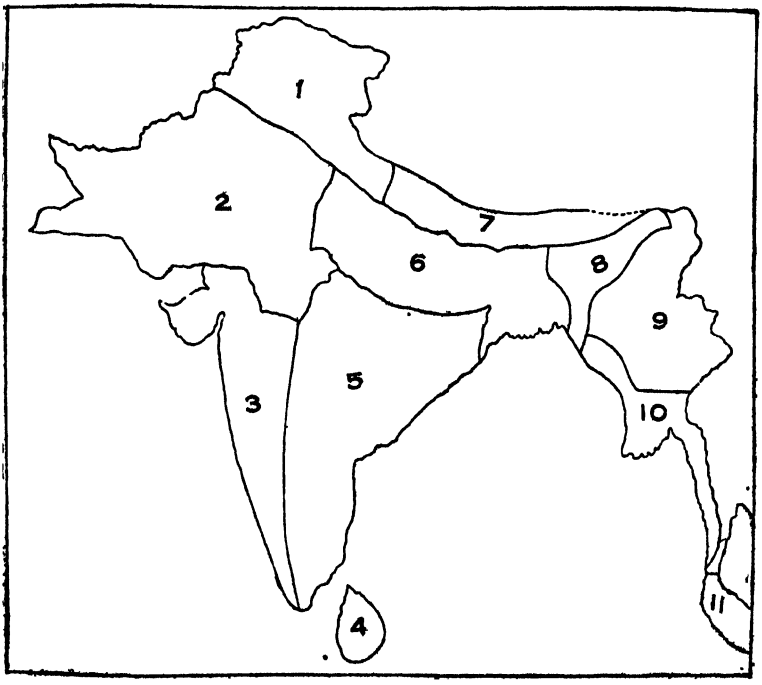
Plant Geographical Regions of India

I have divided India as is shown in the catalogue into eight Phyto-geographical regions: the Deccan comprising the major part of Madras, Hyderabad and Mysore; Malabar consisting of the major part of the Bombay Presidency and the State of Travancore; the Indus Plain—subdivided into the dry desert



MAP 1.—Map showing India and the surrounding countries. Possible routes of immigration of plants from various countries are shown by arrows.

region of Sind, Rajputana and part of Baluchistan and the humid region of the Punjab; the Gangetic Plain with an upper dry region extending from the Punjab over the greater part of the United Provinces as far east as Allahabad, and a lower humid region including the rest of the United Provinces, Bihar and Orissa, and Bengal excepting the areas in the Gangetic delta which form the next subdivision the Sundarbans; Assam; Eastern Himalayas including the Darjeeling district of Bengal, Sikkim and Bhutan and extending to the Mishmi Hills; Central

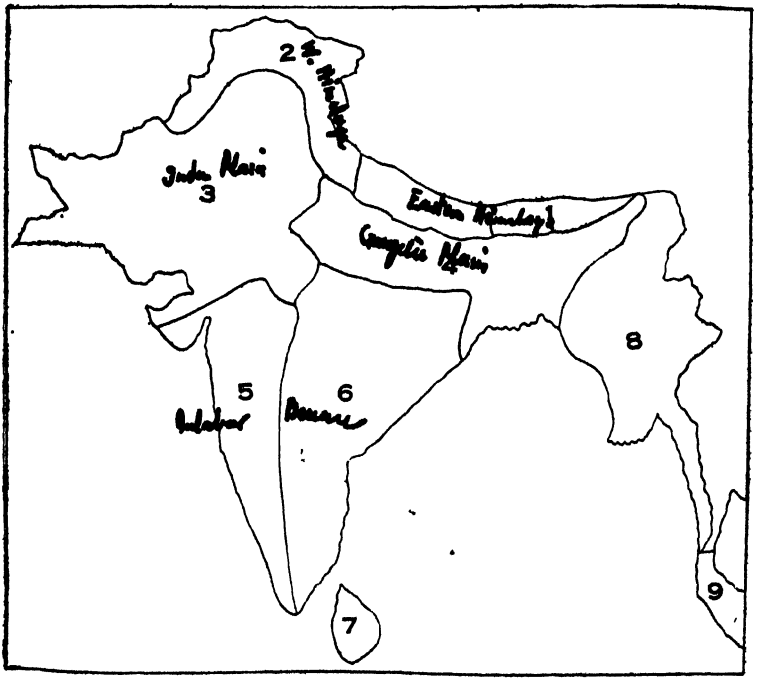


MAP 2.—Map showing Phyto-Geographical Divisions of India as proposed by C. B. Clarke. (1898).

Himalayas—Nepal; and, Western Himalayas extending from the Kumaon Hills through Kashmere to the North-West Frontier Province.

As already stated this arrangement differs somewhat from those proposed by Hooker and by Clarke, which, along with the modified arrangement now suggested, are set out in the following table. The numbers in brackets before the name of each region indicate the sequences followed by respective authors, which are also retained in the following maps.

Clarke, C. B.	Hooker, J. D.	Present writer.
(1) West Himalaya	(2) Western Himalaya	(8) Western Himalaya
(2) India Deserta	(3) Indus Plain	(3) Indus Plain
(3) Malabaria	(5) Malabar	(2) Malabar
(4) Ceylon	(7) Ceylon and Maldives.	
(5) Coromandalia	(6) Deccan	(1) Deccan
(6) Gangetic Plain	(4) Gangetic Plain	(4) Gangetic Plain
(7) East Himalaya	(1) Eastern Himalaya	(6) Eastern Himalaya
(8) Assam		(5) Assam
....		(7) Central Himalaya
(9) Ava	(8) Burma	(9) Upper Burma
(10) Pegu		(10) Lower Burma
(11) Malaya Peninsula	(9) Malaya Peninsula	



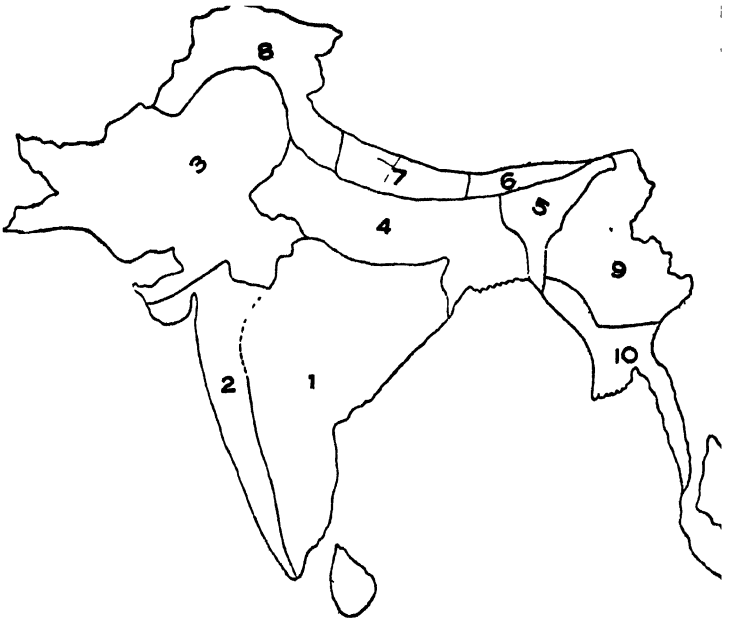
MAP 3.—Map showing divisions of India as proposed by J. D. Hooker. (1907).

The limitations of the various regions defined by Hooker, Clarke and myself are shown in the three accompanied maps. (Maps 2, 3, and 4).

The reasons for the modifications which have been made in the last map are as follows:—

(i) In the first place Hooker and Clarke both included Ceylon and Malaya, but since these regions have floras which are distinctly foreign to that of India, they have been excluded from my review.

(ii) Secondly, whereas Hooker includes the province of Assam in the Gangetic Plain, here, following Clarke, it is excluded and considered as a separate region because of its distinctive flora.



MAP 4.—Map showing the modified arrangement of Indian areas as proposed by the author.

(iii) Thirdly, I have divided the Himalayas into three regions keeping Nepal—the Central Himalayas, as a separate region.

(iv) Moreover I have somewhat altered the sequence of the areas taking the Deccan and Malabar first in consideration of the older geological age of these areas in comparison with the Himalayas.

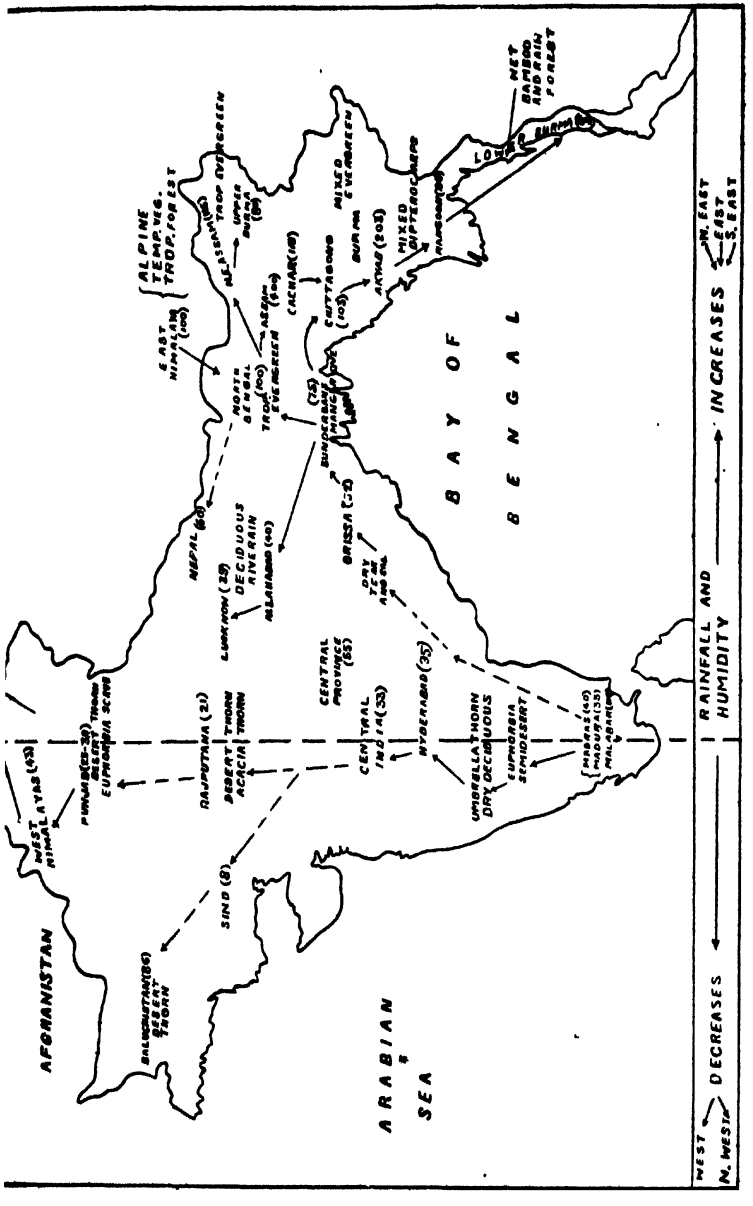
INTER-RELATIONSHIP OF THE INDIAN REGIONS

In a continent as large as India it will be remarkable to find great uniformity in the distribution of species; actually the

vegetation in different regions is very diverse. That of the Deccan, Central India, Rajputana, and the Western Himalayas contrasts with that of Malabar, Lower Gangetic Plain, Assam, and Lower Burma and the striking floristic differences between these regions can in the main be explained by variation in rainfall and humidity, though factors of soil and altitude must also be taken into account. Reference to any rainfall map of India will show that whereas the rainfall is very high in Malabar, Assam, and Lower Burma, it is on the contrary very low in Hyderabad, Rajputana, Sind, and the Western Himalayas. Broadly speaking, this corresponds, on the one hand, to a vast arid area where the vegetation is comparatively uniform with *Acacia arabica* as the dominating plant, forming with associated species a scrubby or thorny growth; and, on the other hand, to a wet area, where tropical forests with most luxuriant growth and with species occurring in great mixture, must be regarded as the climax community. Within this wetter area there is less uniformity of species than in the drier zone and this is well illustrated by the distribution of certain groups of plants and prominent species. As an example *Dipterocarpaceæ* may be cited, where the distribution of different species is determined by comparatively small variation of rainfall. Here species belonging to the same family and sometimes to the same genus show striking contrast in their habit and behaviour. In the genus *Dipterocarpus* itself there are two groups—species which favour a drier environment such as *D. obtusifolia* Teysm. and *D. tuberculatus* Roxb., and others which are of a more hygrophilous type such as *D. turbinatus* Gærtn. *f.*, *D. indicus* Bedd., *D. pilosus* Roxb., and *D. alatus* Roxb. In general, these two groups show further contrast in that the xerophilous species almost always occur gregariously and are deciduous, while the hygrophilous species occur sporadically and are evergreen.

On the contrary with its limited distribution, the *Sal* (*Shorea rubusta* Gærtn. *f.*) seems to be less directly influenced by rainfall than by other factors, for it is the typical plant over a large tract of country where the rainfall is by no means uniform. There are two main centres of development of this species. First in the foothills of the Himalayas where it extends in almost unbroken succession from the Kangra Valley in the east Punjab to the Darrang district of Assam, and the second region in central India extending from the Santal Parganas southwal to Chota Nagpur reaching the Ganjam district of the Madras Presidency. It is noteworthy that in the Gangetic Plain which separates these two regions, *Sal* is entirely absent—and this can only be explained by factors of climate and soil.

In the hilly or mountainous regions—the Himalayas, the hills of Khasia, Burma and the Nilgiris, altitude is of course the dominating factor in determining the vegetation. It may be remarked that although these regions are widely separated the



MAP 5. Map showing the vegetational types of India and their variations with rainfall and altitude.

vegetation of the upper subtemperate regions is closely similar in all. In every instance the lower zone is characterised by rainforests—composed of a large number of species occurring in mixed association, but in the Himalayas with a marked contrast between the drier western side with a sparse vegetation and the central and eastern side, where the growth is more luxuriant. In the higher zone, *Cedrus deodara* and *Pinus excelsa* dominate in the west, and *Pinus khasya* is the ruling species in similar levels in Assam and the Naga Hills. A zone of *Oak* and *Chestnut* forest with *Magnolias* and *laurels* ranges from 8 to 10,000 feet with *conifers* in small patches, and above this *Rhododendron* forest to 12,000 feet leads to the upper alpine meadows where only shrubs and herbaceous plants survive.

To summarise the facts and to explain the relationships of the main vegetational types as they occur in various regions of India with different rainfall, the accompanied diagram is given. (Name of each place is followed by a number in bracket indicating the total annual rainfall in inches.) *See map on page* 27.

Emphasis has been laid upon the diversity of the vegetation of different areas; at the same time it may also be remarked that certain species are very characteristic of certain areas. Some genera and species are very localised, others have a wide distribution.

An attempt to observe how far the distribution of plants from outside India has influenced the original flora of the country, leads us to the question of endemism; but before going into detail of the endemic and non-endemic elements of the Indian flora, the subject of endemism will be discussed first in the following lines from a more general point of view.

ENDEMISM

(*A*) *General Treatment*:—The word endemic is generally used to mean a species, genus, or other group confined to a small area. In recent years species which are confined to comparatively large areas are also spoken of as endemics. The endemic state of a species or of a genus is variously described. Some hold the view that endemic species or genera are the survivals of the larger groups of the past which are now in course of gradual extinction, while others maintain that they are new and recent forms of gradually extending plant-groups. The supporters of the former view put forward the examples of *Tree ferns*, and *Ginkgo biloba* which are endemic in their respective regions, while those who support the latter view would cite examples like the numerous endemic species of *Impatiens*, *Primula*, *Rhododendron*, and *Gentiana*. It is possible that both schools are correct in their views, but from the evidence of the large number of new

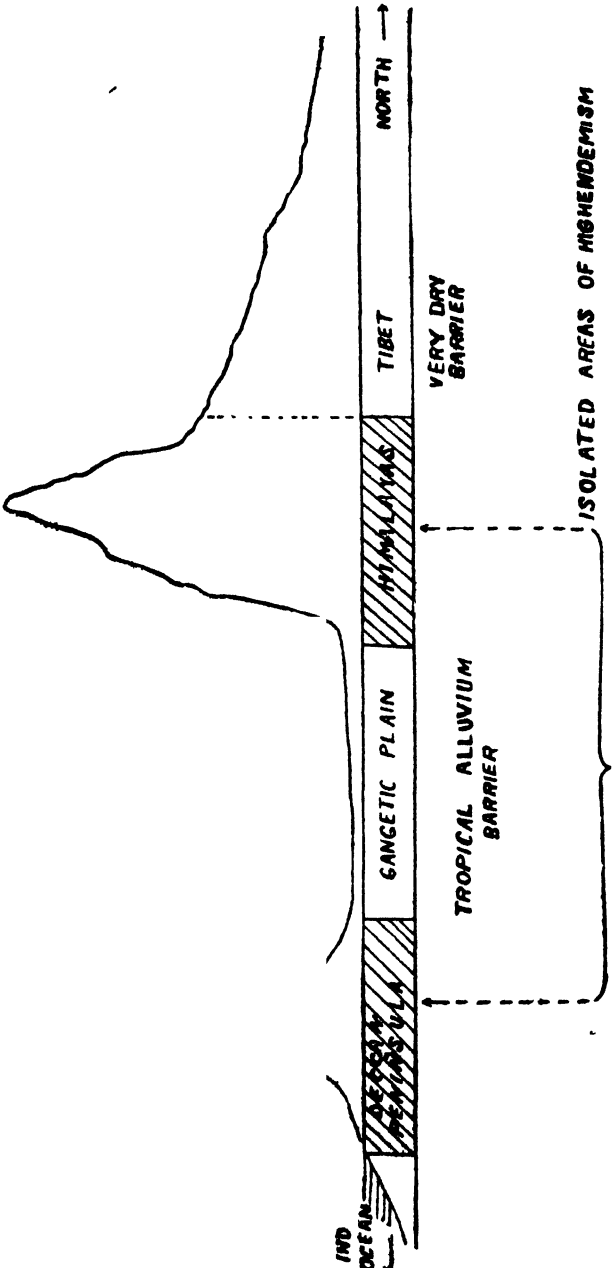


FIG. 1.—Diagram showing how the barriers of Tibet and Gangetic Plain have induced endemism in South India and the Himalayas.

forms, continually arising by natural crossing and mutation, it is quite likely that the latter view has more supporters.

The main factors responsible for the production of endemic species are mutation and natural crossing amongst closely allied plants growing in a favourable locality. The effect is further enhanced by the removal of outside influence which in other words means the creation of a state of '*isolation*'. The vegetation of Oceanic islands is a good example, for there a large percentage of the flora is endemic. For example, 82 percent of the species in Hawaii Islands are endemics, 72 percent in New Zealand, and 50 percent in Fiji Islands. The high percentages of endemic species in each of the above groups of islands have been produced in great measure by their isolation. Some parts of continental areas often show a high degree of endemic contents, and it may be found that these areas also present special forms of isolation. The most usual forms of these are either a lofty mountainous chain or a very dry region (desert, etc.), separating two land areas. A typical example is the Himalayan range—a very interesting area with high percentage of endemic species. This range has the warm alluvial plains of India to the South and the dry Tibetan plateau to the North. Consequently the species that compose the temperate and the alpine vegetation of the Himalayas have freely formed new species within this area, but these have been unable to migrate freely, either north or south. This physical isolation in a continental area as shown by the Himalayan range has produced endemism in various parts, as is shown by the diagram on page 29.

It is probable that the distribution of endemic species gives some indication of their age. Willis in his 'Age and Area' proposes the theory that all endemic species which occupy a smaller area are to be regarded as younger species—a point of view which seems to be correct for a large number of species, but certainly not for all. In other words, he emphasises that the frequency of a species over an area varies directly with its age in evolution. He has further supplemented his statement by the following figures of endemic species from Ceylon:—

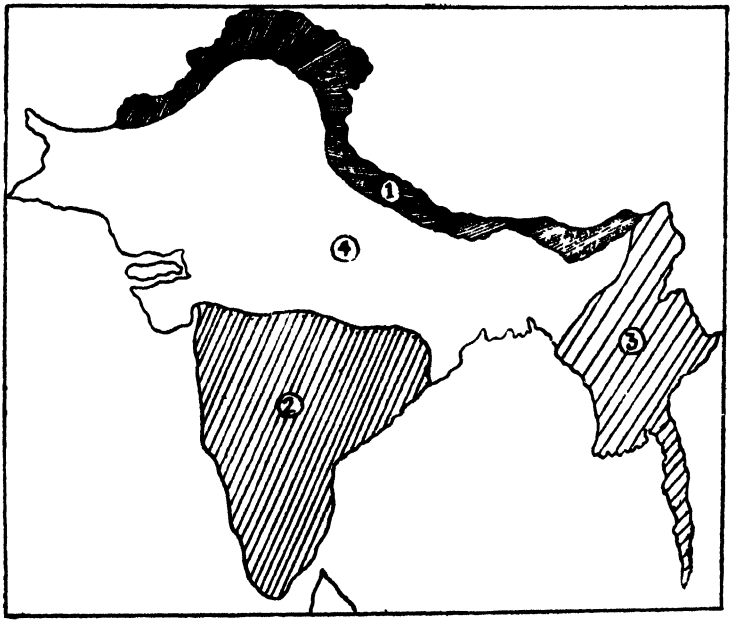
Common in the whole area ..	90
Rather common	139
Rather rare	136
Rare	192
Very rare	233

Somewhat similar figures for the Indian area have been worked out by me and they seem to favour Willis' view.

Number of endemic species common generally in India	533
Number of endemic species in the Himalayas only	3,165

Number of endemic species in Continental India	2,045
Number of endemic species in Burma ..	1,071

From the above two sets of figures for Ceylon and India it seems very reasonable to regard endemic species as new forms, produced from a stock capable of change. These new forms, not having had the opportunity or the time for migration, are thus localised and are not found over an extended area. This seems to be a possible general explanation of endemism in plants and



MAP 6.—Map showing divisions of India according to endemic values. Shaded areas (1), (2), and (3) show the degree of endemicity in different parts; (4) represents area of low endemism

the view of 'relic' or 'survival species', although true for some plants, may have much less significance in the general theory.

(*B*) *Endemism in India*:—As India is a part of the largest continent in the world, its general flora has been influenced by the widely separated countries that surround it. An approximate estimate of the Indian Dicotyledons shows that 61·5 percent of the plants are endemic. This figure is definitely very high for a continental area with land connections in three directions, east, north, and west. In India there are three regions containing a specially large number of endemic species and these

jointly contribute to this high percentage for the whole country. These regions are (i) The Himalayas, (ii) The Indian Peninsula forming 'Continental India', and (iii) Burma. The rest of India—the Indo-Gangetic plains and the desert regions of Sind, Rajputana and the dry regions of Baluchistan,—form an area which is extremely poor in endemic content. The variation of the intensity of the endemic population is shown in map 6 on page 31.

It is clear from the map that the northern part of India is completely occupied by the lofty mountains of the Himalayan range. The effective nature of this as a barrier to plant-migration has already been pointed out. This barrier is separated from Continental India by a broad and dry plain which has cut off that region from close contact with the northern flora, thus affording a large independent area with a high endemic population. The Deccan Peninsula contains no less than 2,045 endemic species and is thus not far behind the Himalayas with 3,169 endemic species. How far land connections between Malayasia, India, and Africa have influenced the present flora of the Deccan Peninsula is difficult to indicate with any degree of precision.

Burma is another region very rich in endemic contents. It is connected on three of its sides with other countries and intermigration of its flora has taken place. None the less the outside influences are not too manifest in the Burmese flora. There are two main tendencies of immigration into Burma—a Chinese one from North-East which will concern chiefly temperate and alpine plants and a Malayasian influence from South-East bringing in a more tropical flora. In spite of these foreign immigrants, as many as 1,071 species are localised in Burma.

In its comparatively high endemic percentage for a continental region, India (with 6,850 endemic species, 134 endemic genera, and 61·5 percent endemic flora) may be compared with the following countries.

Countries.	Total sp.	Percentage of endemism.	Number of endemic genera.
Ceylon	800	30%	23
New Zealand	1,000	72%	32
Australia	7,500	80%	470
Hawaii Is.	600	82%	45
California	1,416	40%	not available.

The total number of species recorded from India with the number of 'Wides' and the proportions of endemic species in different regions is shown by the following table.

Total No. sp. (Dicot)	Total No. Genera.	Wides.	Endemics.			
			Cont. India.	Himal. with Assam.	Burma.	Gen. Area.
11,124	1,831	4,274	2,045	3,169	1,071	533
Percentage	..	38·5	18·2	28·8	9·6	4·9
		38·5	61·5			

100

Note.—The total figure includes about 32 species of doubtful nature or of which exact localities are unknown (being referred as only from India.)

This is expressed diagrammatically as :—

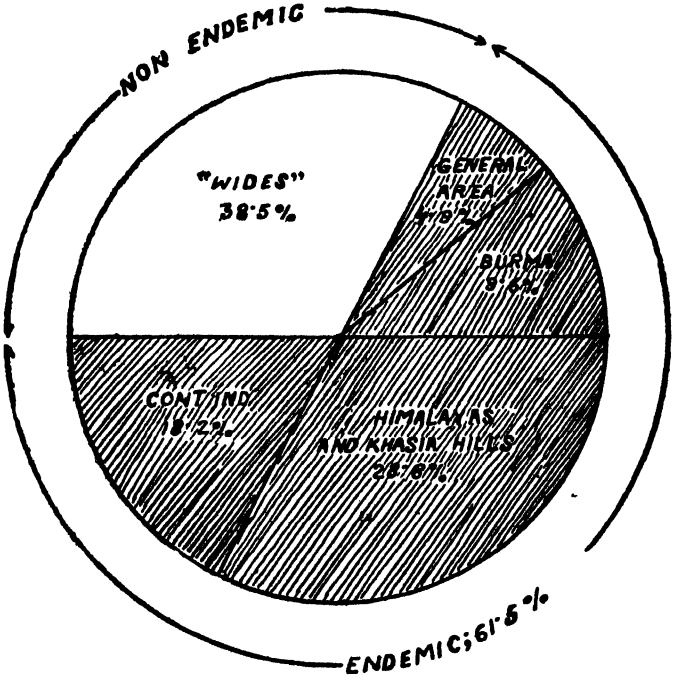


FIG. 2.

The endemic percentages of these three areas (i.e. Continental India, Himalayas and Burma), if calculated on the basis of each area and not on India and Burma as a whole, would obviously be very much higher. They would range from 50% to at least 70%, the higher ratio being undoubtedly in the Himalayan region. (This would however mean a much more elaborate calculation.)

Non-Endemic Elements in the Indian Flora

As has already been stated there are 38·5 percent of the total plants in India which occur as 'Wides.' This means they are found in other countries also. These non-endemics appear to me to fall into the following categories:—

(i) Species chiefly tropical and sub-tropical of fairly wide distribution in Asia, and sometimes beyond.

(ii) A considerable number of species of limited distribution occurring just beyond the boundaries of our area, e.g. S.W. China, Siam, Tibet and Afghanistan. They cannot be reckoned as endemics if we adhere to the geographical boundaries as we must, but in many cases they are very localised.

(iii) Non-endemics associated with cultivation and therefore of wide distribution, as well as certain introduced plants.

Further points arising under this section will be discussed in the next section where I deal with individual families and genera.

Commentary on the Endemism, Relationship and other special Features of some Indian Families

The Dicotyledons in India are represented by 173 families. They may be arranged in three groups as follows:—

(A) Families containing less than 20 species in each.

(B) Families containing 20 or more species in each, and with a majority (more than 50%) of species *Non-endemic* or *Wides*.

(C) Families containing 20 or more species in each, and with a majority (more than 50%) of species *Endemic*.

(A) Following are the families that belong to the first group. (Number within brackets at the end of each name indicates the total number of species in India):—

Dilleniaceæ (15), *Schizandraceæ* (5), *Lardizabalaceæ* (5), *Nymphæaceæ* (11), *Resedaceæ* (4), *Bixaceæ* (1), *Cochlospermaceæ* (1), *Pittosporaceæ* (8), *Xanthophyllaceæ* (7), *Frankeniaceæ* (1), *Portulacaceæ* (6), *Tamariscaceæ* (8), *Elatinaceæ*

(6), *Ancistrocladaceæ* (5), *Linaceæ* (8), *Erythroxylaceæ* (6), *Malpighiaceæ* (17), *Zygophyllaceæ* (9), *Oxalidaceæ* (14), *Simarubaceæ* (15), *Ochnaceæ* (9), *Burseraceæ* (13), *Dichapetalaceæ* (3), *Olacaceæ* (18), *Opiliaceæ* (4), *Staphyleaceæ* (4), *Hippocastanaceæ* (2), *Sabiaceæ* (19), *Coriariaceæ* (1), *Droseraceæ* (4), *Hamamelidaceæ* (7), *Halorrhagidaceæ* (14), *Rhizophoraceæ* (16), *Hernandiaceæ* (4), *Lecythidaceæ* (12), *Crypteroniaceæ* (3), *Sonneratiaceæ* (5), *Passifloraceæ* (7), *Caricaceæ* (1), *Turneraceæ* (1), *Datiscaceæ* (2), *Cactaceæ* (6), *Aizoaceæ* (16), *Alangiaceæ* (6), *Cornaceæ* (12), *Nyssaceæ* (2), *Dipsaceæ* (17), *Stylidaceæ* (3), *Goodeniaceæ* (2), *Monotropaceæ* (3), *Diapensiaceæ* (1), *Plumbaginaceæ* (8), *Styracaceæ* (9), *Salvadoraceæ* (5), *Menyanthaceæ* (1), *Polemoniaceæ* (1), *Hydrophyllaceæ* (1), *Pedaliaceæ* (4), *Plantaginaceæ* (13), *Nyctaginaceæ* (8), *Illecebraceæ* (2), *Podostemaceæ* (16), *Nepenthaceæ* (1), *Cytinaceæ* (1), *Aristolochiaceæ* (13), *Chloranthaceæ* (3), *Myristicaceæ* (14), *Hernandiaceæ* (1), *Proteaceæ* (7), *Elæagnaceæ* (12), *Santalaceæ* (15), *Balanophoraceæ* (6), *Buxaceæ* (6), *Ulmaceæ* (16), *Cannabinaceæ* (2), *Platanaceæ* (1), *Juglandaceæ* (4), *Myricaceæ* (1), *Casurinaceæ* (1), *Ceratophyllaceæ* (1).

This group contains 81 families. Most of them consist of species which have a wide distribution and do not invite any special explanation. Some of them are interesting from the point of view of distribution, and the main features are as follows :—

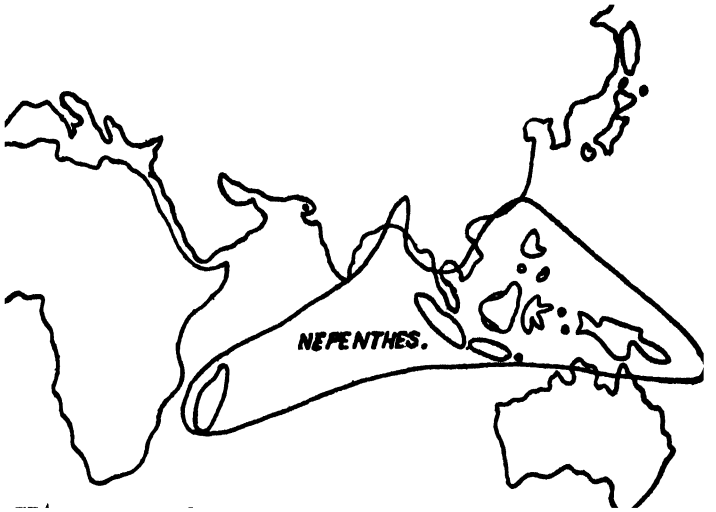
(i) *Dilleniaceæ*, *Pittosporaceæ* and *Proteaceæ* have their greatest development in Australia, and their presence in India along with such families like *Halorrhagidaceæ*, *Myristicaceæ*, and partly *Santalaceæ*, clearly point to the Malayasian and Australian influence in India.

(ii) The distribution of *Nepenthaceæ* in Assam is the northernmost limit reached by the genus. As has been pointed out by Hutchinson (Fam. Fl. Plants. Dicot. 105), the range of distribution of this remarkable genus indicates a certain relationship between the island of Madgascar and Malayasia through Ceylon and Khasia Hills. The map 7, on p. 36, shows the distribution of *Nepenthes* (after Hutchinson).

The genus *Ancistrocladus Wall.* which has now been raised to the rank of a family (being separated from *Dipterocarpaceæ*) has an interesting distribution in West Africa and India shown in map 8, on p. 36.

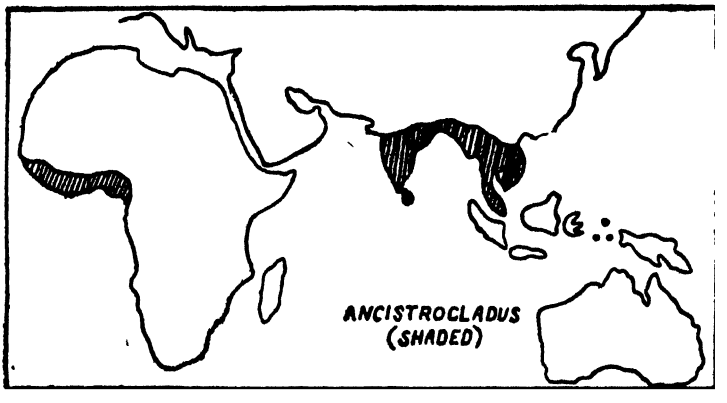
These two cases are prominent among the comparatively few examples of close association of India with the African flora.

(iii) A third set of Families consists of *Rhizophoraceæ* (Mangrove), *Sonneratiaceæ* (Mangrove), *Nymphaeaceæ* (water plants) and *Ceratophyllaceæ* (water plants), whose wide distribution is explainable from the nature of their environment and special adaptations for distribution through water currents.



MAP 7.

It is interesting to note that although *Rhizophoraceæ* are represented in India by 16 species, of which 15 are found elsewhere in Malayasian and East Australian shores, there is one monotypic genus (*Blepharistemma* Wall.) which is localised in the small area of Malabar in South India.



MAP 8.

(iv) The family *Malpighiaceæ* has its greatest development in South America forming a marked feature amongst the tropical lianes. Its presence in the Indian region with 7 endemic species, and also in Malaya is remarkable. Although a few species are also found in Africa and Madgascar, it is difficult to advance any explanation of the spread of this family in South East-Asia.

(v) The family *Podostemaceæ* form another interesting ecological group in India. The species of this family, mostly tropical, are characterised by living only in rushing water and growing on rocks in shallow rivers. The chief centre of distribution in India is to be found in South India with occasional species in Khasia, in Burma, and in the subtropical part of Eastern Himalayas. The Indian species show a high endemic ratio; of the 16 species, only 5 are *wides* and the rest are endemic, with 9 species endemic in South India alone.

(vi) Families like *Hamamelidaceæ*, *Oxalidaceæ*, *Olacaceæ*, *Cornaceæ*, *Dipsaceæ*, *Styracaceæ*, *Elæagnaceæ*, though not forming a homogeneous group, clearly show a North-East Asiatic influence. *Styracaceæ* have really three centres of distribution of which two are in America. The third line which extends from Japan to Java, touches Burma, Sikkim and Khasia where some of the species and one monotypic genus (*Parastyrax* W. W. Smith) have been found. *Hamamelidaceæ* are also distributed from North America through Japan and China until they reach Sikkim, Khasia and Burma. *Elæagnaceæ* have a much wider distribution throughout the temperate regions from Northern Europe to North-East Asia and North America and have just touched the North Indian region.

(B) Following families belong to the second group:—

Menispermaceæ (42), *Violaceæ* (25), *Polygalaceæ* (32), *Malvaceæ* (111), *Sterculiaceæ* (80), *Tiliaceæ* (78), *Elæocarpaceæ* (42), *Geraniaceæ* (28), *Rutaceæ* (71), *Aquifoliaceæ* (34), *Sapindaceæ* (54), *Connaraceæ* (20), *Cæsalpiniaceæ* (124), *Mimosaceæ* (96), *Myrtaceæ* (116), *Lythraceæ* (48), *Cucurbitaceæ* (87), *Convolvulaceæ* (177), *Solanaceæ* (58), *Sorophulariaceæ* (273), *Orobanchaceæ* (29), *Bignoniaceæ* (31), *Verbenaceæ* (115), *Amarantaceæ* (48), *Chenopodiaceæ* (40), *Thymelæaceæ* (22), *Moraceæ* (113).

This group of 27 families which have most of their species distributed widely contains a few temperate ones of some interest.

(i) It is rather unexpected to find that *Violaceæ*, *Polygalaceæ* and *Thymelæaceæ* (which are generally found in temperate regions) have their species so widely distributed as to put them outside the group of families with greater endemic values. The genus *Viola* has been recently revised and a large number of Himalayan species are now reported from the Yunnan area, and thus the endemic index of the family has been considerably

lowered. The family *Polygalaceæ* is cosmopolitan (except for New Zealand and Polynesia) and has many widely distributed species. The family *Thymelaeaceæ* occurs both in temperate and tropical regions with its greatest development in Africa. The genus *Daphne* is represented in the Himalayas and the Khasia with some six species which are all endemic, but the occurrence of widely distributed genera like *Thymelœa*, *Edgeworthia*, *Wikstroemia* and *Stellera*, has reduced the endemic index of the family as a whole.

(ii) *Menispermaceæ*, *Malvaceæ*, *Sterculiaceæ*, *Tiliaceæ*, *Cœsalpinaceæ*, *Mimosaceæ*, *Convolvulaceæ*, *Scrophulariaceæ* (in great part), and *Moraceæ* form a tropical group, with a wide range of distribution and it is to be expected that they do not have a high percentage of endemics in any particular region in India.

In *Moraceæ* the tropical genus *Ficus* with a large number of species is worthy of some comment. The genus, the tenth largest in our area is represented by 86 species. The chief centre of development of the genus may well be Malayasia and South Burma and the species though found largely in adjacent countries do not travel very far from the Indo-Malayan region.

Another very remarkable family in this group is *Myrtaceæ*, of which the chief centres of development are in Australia and South America. The most important genus found in India is *Eugenia* (including *Syzygium*, and *Jambosa*) with 103 species. They are mostly distributed in Continental India. Species of *Eucalyptus* are found in the Hill Stations of India which however are all introductions from Australia.

Cucurbitaceæ, *Solanaceæ*, *Amarantaceæ*, *Chenopodiaceæ* and partly *Rutaceæ* contain many species which have found their way to India as weeds of cultivation, and subsequent naturalisation.

The family *Aquifoliaceæ* represented by only one genus *Ilex* contain 34 species in India. The genus is well known for its wide distribution. Its species are found in North and South America, Asia, Africa and Europe and it is quite natural that most of the Indian species are found also in the adjoining parts of Asia. The endemic percentage of *Ilex* in India is 38%.

(C) The following families belong to the third group:—

Ranunculaceæ (163), *Magnoliaceæ* (36), *Anonaceæ* (129), *Berberidaceæ* (35), *Cruciferæ* (178), *Fumariaceæ* (66), *Papaveraceæ* (45), *Capparidaceæ* (65), *Flacourtiaceæ* (21), *Caryophyllaceæ* (107), *Hypericaceæ* (26), *Guttiferæ* (40), *Ternstroemiaceæ* (39), *Dipterocarpaceæ* (51), *Balsaminaceæ* (242), *Icacinaceæ* (25), *Meliaceæ* (62), *Celastraceæ* (84), *Hippocrateaceæ* (27), *Rhamnaceæ* (53), *Ampelidaceæ* (69), *Leeaceæ* (27), *Aceraceæ* (20), *Anacardiaceæ* (67), *Papilionaceæ* (867), *Rosaceæ* (257), *Saxifragaceæ* (114), *Crassulaceæ* (64), *Melastomaceæ* (127), *Combretaceæ* (52), *Onagraceæ* (39), *Samydaceæ*

(20), *Begoniaceæ* (71), *Umbelliferæ* (180), *Araliaceæ* (56), *Caprifoliaceæ* (55), *Rubiaceæ* (551), *Valerianaceæ* (20), *Compositæ* (696), *Campanulaceæ* (71), *Vacciniaceæ* (68), *Ericaceæ* (146), *Primulaceæ* (208), *Myrsinaceæ* (94), *Sapotaceæ* (32), *Ebenaceæ* (58), *Symplocaceæ* (51), *Oleaceæ* (97), *Apocynaceæ* (89), *Asclepiadaceæ* (234), *Loganiaceæ* (40), *Gentianaceæ* (189), *Boraginaceæ* (145), *Lentibulariaceæ* (30), *Gesneriaceæ* (133), *Acanthaceæ* (514), *Labiatæ* (421), *Polygonaceæ* (110), *Piperaceæ* (104), *Lauraceæ* (172), *Loranthaceæ* (73), *Euphorbiaceæ* (444), *Urticaceæ* (109), *Cupuliferæ* (64), *Salicaceæ* (44).

There are 65 families in this group. These do not have very much uniformity in their distribution, although everyone contains more than 50 percent of species endemic to India. Some families are tropical, others are temperate, some have their allies in the dry Orient, while others are related to the Chinese or Malayasian floras. In view of their high endemism and interesting distributional features the majority of the families of this group need a somewhat detailed account:—

Ranunculaceæ:—The members of this family as represented in India are mostly found in the Himalayas, in Upper Burma and in the temperate regions of the Nilgiri Hills. The main centre of Ranunculaceæ is undoubtedly in the north temperate hemisphere and so far as the Indian species are concerned, their presence is clearly due to the result of an invasion from the north. The degree of endemicity of certain Ranunculaceous genera is well worthy of consideration and their endemic percentages are as follows:—

Ranunculus	..	36%
Anemone	..	43%
Clematis	..	76%
Thalictrum	..	79%
Delphinium	..	71%
Aconitum	..	90%

The first four have actinomorphic flowers and the last two zygomorphic. Although the percentage in *Clematis* and *Thalictrum* is high there would appear to be a marked difference between actinomorphic and zygomorphic forms. It could be argued that the zygomorphic genera show a greater tendency to an evolution of new species while the actinomorphic genera might be regarded as more stable. One cannot, however, push this argument too far, yet a general tendency would appear to be indicated by the figures quoted. The low percentage of endemicity in *Ranunculus* may quite well be due to the weedy character of many of its members which would account for a considerable number of "wides" in its composition.

It must be confessed that it is difficult to see why *Clematis* and *Thalictrum* should show so high a percentage of endemics,

when *Ranunculus* and *Anemone* with similar floral structures do not present endemic species to the same degree. It seems quite probable, that besides the weedy nature of *Ranunculus* as has already been pointed out, there exist other factors, other than actinomorphy, which are responsible for this marked tendency towards specific multiplication in *Clematis* and *Thalictrum*.

In considering the distribution of certain genera of Ranunculaceæ it is worth recording that *Actæa spicata* Linn. and *Cimicifuga fœtida* Linn. have a very wide range not only in India where they occur in the Himalayas but also in North Asia, Europe and North America. A marked contrast with the above is shown by certain genera of restricted distribution, such as *Calathodes* Hook. *f. & T.*, occurring in the Eastern Himalaya and Hupeh and *Beesia* Balf. f. et W. W. Smith, found to occur in Upper Burma and the adjoining parts of Yunnan.

Magnoliaceæ:—The Magnoliaceæ with a very discontinuous distribution are found in temperate and sub-tropical regions of the world. The main trend of their occurrence extends from the Himalaya, China, Japan to North America, and naturally the Indian species are found in the Eastern, and South-Eastern part of the country. This discontinuous distribution of the family indicates its great antiquity; at the same time the evidence of the anatomical structure of the wood of many species and the multiple arrangement of the floral parts support this statement. It is however significant that unlike some old families, *Magnoliaceæ* is full of localised endemic species. For example, all the Indian species of *Illicium*, *Talauma*, and *Magnolia* are endemic and a high endemicity is shown in *Manglietia* and *Michelia*, which are 80 and 73 percent respectively. This surprisingly high endemic content in a primitive group like this is rather difficult to explain. A view might be put forward, based chiefly on the effect of their tree habit. The species mostly grow as lofty trees and may live beyond 100 years. It is quite possible that during this period, while a herbaceous group like *Ranunculaceæ* regenerating annually, or at any rate frequently, gets a much greater chance of specific variation in certain of its members, the lofty *Magnolia* would produce viable seeds only for a limited number of times and is thus handicapped in the creation of new species. This is perhaps one of the causes why the species of this family have remained so very localised while the group itself is very old.

Anonaceæ:—An admirable account of the distribution of this family has been made by Hitchinson in Kew Bulletin 1923: 243. The *Anonaceæ* are confined to the tropics, found abundantly in the rainforests of Brazil, Western Africa, Ceylon, South Burma and Malayasia. It has been pointed out that the species of the two hemispheres have a difference in habit. In old world they are usually of a climbing or straggling nature and occur in the dense forests, but in Tropical America they are nearly

all shrubby or arboreal and grow on open grassy plains. The genera are mostly localised except for *Xylopia* found in S.E. Asia, Central and West Africa and South America and *Anaxogarea* with a disconnected distribution in South East Asia and Brazil.

The India *Anonaceæ* are all confined to the tropical parts of the Deccan, Assam, and South-Burma and not a single species is found in the temperate regions of the Himalayas.

Dealing with a tropical family like this, we would expect to find a comparatively low endemic percentage, but 60 percent of the Indian species are endemic. Although members of a widely distributed family the relationship of the Indian species of *Anonaceæ* is clearly to be sought with the Malayasian members, as we find in South Burma a great concentration of *Anonaceæ* of Malayasian affinity.

Berberidaceæ:—From the point of view of endemism the interesting genera of Berberidaceæ are *Berbaris* and *Mahonia*. The general distribution of these is in the north-temperate zone extending from North Asia, Northern Europe to North America and in some degree to South America. In this family there is a very large number of endemics, for 97 percent of the Indian species are not found elsewhere.

Whatever may be the reason for this high figure of endemism, it is one of the largest in the present analysis. It is generally believed that *Polypetalous* families are less equipped for specific variation than the *Gamopetalous* group. It is difficult to see why the effects of evolution or progressive variation, would favourably accelerate only the *Gamopetalæ* and not many members of *Polypetalæ*. It is quite evident that the formation of new species has taken place equally in *Berberidaceæ* as in many progressive *Gamopetalous* families. This view if further supported by the fact that in cultivation the species of *Berberis* hybridise very freely.

The general habit of *Berberis* suggests xerophytic conditions yet in India most of the species are found in the humid central and eastern Himalayas. Very few species are found in the dry N.W. Himalayas. The Indian plants of *Berberis* and *Mahonia* are obviously related to the Chinese species of Yunnan and the adjoining areas, where many species occur.

Cruciferæ:—The family is represented in India chiefly in the Western Himalayas and the drier regions of N.W. India. There are a few species in the eastern Himalayas and the plains of India, but the whole of South India lacks representatives of this family except for the cultivated species and a few weeds associated with them. A great development of the members of this family is found in the Mediterranean region and a possible connection with the Indian area can be sought through Persia and Afghanistan. The total endemic percentage is only 56 which however is quite a high figure for a presumed invading family. In some particular

genera the percentages are higher and mention can be made of *Draba* (83%), *Cardamine* (70%), and *Arabis* (71%)—practically all high alpines.

Fumariaceæ:—This family follows somewhat similar lines of distribution to the *Ranunculaceæ*, *Berberidaceæ* and *Cruciferæ*. The only genus worth comment is *Corydalis*, which is perhaps best developed in the Himalayan and the West Chinese areas. A map showing the distribution of *Corydalis* has been made by Hutchinson in Kew Bulletin 1921 : 97, which clearly shows its wide range in the northern Hemisphere. The endemic figure of the Indian species is very high, for 48 species are endemic out of a representative of 61 which brings the percentage to 79.

Evidence is strong in supporting the view that as a genus the main development of *Corydalis* has taken place in Central Asia and the Himalayas from where it has migrated east and west. It is however interesting to note that in their Himalayan development the genus is stronger in Western dry part.

A somewhat localised genus of the family is *Dactylicapnos* Wall. (syn. *Dicentra Borkh*) which ranges from Kumaon to Khasia and Yunnan.

Papaveraceæ:—The only noteworthy genus in this family is *Meconopsis Vig.* which has developed chiefly in Nepal, the eastern Himalaya and western China. An excellent monograph of the genus has been made by Taylor (Genus Meconopsis, 1934). In the Indian region we have 26 species (including 2 species of *Cathcartia*) and all are endemic except one which brings the endemic figure to 96 percent. The development of the genus is very similar to what we find in *Corydalis* with the exception that the concentration of species is more in the moist eastern Himalaya than in the west. The obvious connection of *Meconopsis* is with western China.

It is perhaps worth noting that the tropical American weed *Argemone mexicana* Linn. has established itself widely in the Indian plains.

Capparidaceæ:—In dealing with a family like this which is mainly tropical and subtropical it is natural to find a wide distributional range and so a smaller endemic figure. The endemic percentage of the whole family as represented in the Indian region is 54. The only genus of any size is *Capparis* with 38 species.

The association is cheifly with species of the drier regions of the Orient and Africa and to a much lesser degree with the Burmese region where the number of species is comparatively low. The African relation can be stressed on the further point of a high representation in Continental India.

Burma contains two small monotypic genera—*Hypselandra* Pax et Hoffman, and *Borthwickia* W. W. Smith.

Flacourtiaceæ:—This is a tropical family and found widely in South India and Lower Burma. The genus *Hydnocarpus*

Gærtn. is found in Lower Burma and Malayasia and its species have received attention for their medicinal properties. Sleumer in Bot. Jahrbuch 69. i. (1938) has thoroughly revised this genus and showed in detail its specific distribution. The Indian members of the family as a whole are related to the Malayasian group except perhaps the genus *Gynocardia Br* which is found endemic in Sikkim, Assam and Chittagong hills.

Caryophyllaceæ:—This family follows a similar line of distribution to *Cruciferæ* and the same general statement may be made for it.

Guttiferæ.
Ternstroemiaceæ.
Dipterocarpaceæ.

These three families form a naturally related tropical group with a strong Malayasian tendency.

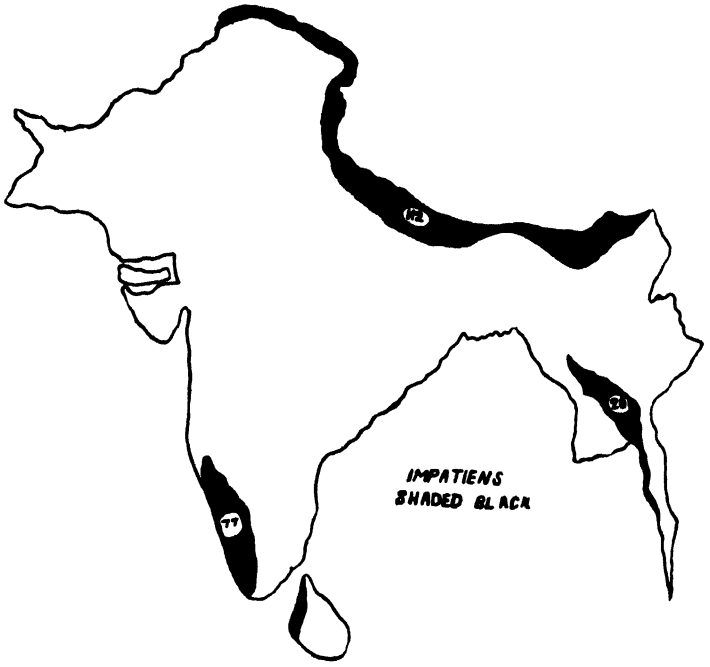
The genera of the family *Guttiferæ* have a varied distribution. *Poeciloneuron* Bedd. is endemic in South India while *Garcinia* L., *Calophyllum* L., *Kayea* wall, and *Mesua* L. are found from Tropical Africa to Malayasia. The general endemic percentage for the family in India is 50, and most of the 'wides' are in Malayasia. This shows that a S.E. Asiatic influence in main is responsible for the *Guttiferæ* in our area.

Ternstroemiaceæ probably has two independent centres of development, one in Tropical Asia and the other in Tropical America. It is remarkable that the representatives of this family are almost wanting in Africa and absent from Australia. The endemic percentage of the Indian species is 54 and 'wides' are also from Malayasia. The genera do not show any striking features as regards their endemism in our area.

Dipterocarpaceæ as a family is confined to tropical Asia and has developed its species in large numbers in two widely separated areas, i.e. Ceylon and Lower Burma. From both, species have travelled into the neighbouring countries. An interesting feature of Ceylon species is their high endemic nature and genera like *Doona* Thw. (10 sp), *Stemonoporus* Thw. (15 sp) and *Monoporandra* Thw. (2 sp) are practically confined to Ceylon. The majority of the genera and species occurring in Ceylon are endemic, so that a few have penetrated into South India. The representative genera of south Burma and Assam are *Dipterocarpus* Gærtn., *Vatica* Linn., *Shorea* Roxb. Hopea and *Parashorea* Kurz. While *Parashorea* is a monotypic genus the other four show a somewhat similar development as regards number of species and approximately the same endemic ratio.

Balsaminaceæ:—This family contains two genera *Impatiens*, and *Hydrocera*. The genera are strongly contrasted as regards number of species. *Impatiens* contains about 550, and *Hydrocera* is represented by only one species (*H. angustifolia* Bl.) found widely in the Asiatic tropics as well as in India.

The genus *Impatiens* has its greatest development in the Indian region and is found chiefly in moist subtemperate areas. The greatest concentration of the species has taken place in the humid Eastern Himalayas and in Burma and this fact naturally leads us to believe that the genus is a northern one. But it is very striking that a great assemblage of species is also found in Southern India and Ceylon. The intermediate regions of the Indus Plain and the Gangetic Plain completely lack species of *Impatiens*. The strong development in South India is thus an interesting example of discontinuity. Here we have a case



MAP 9.

where not even one species is common to the Himalayas and South India although each of these areas contains a very large number of endemic species. In this case the study of endemism of the Indian species shows that the two groups (i.e. the Himalayan and South Indian) must have been separated from each other for a very long time, and have developed along parallel lines each producing its own set of endemic species.

The total number of endemic species in India is 220 out of 241, which brings the endemic percentage to 91. Moreover

the genus is the largest as to number of species in the Indian area. In his detailed study of the genus Hooker expected that it would prove to be so (Rec. Bot. Surv. Ind. Vol. IV. 1904–6) and to-day it is clear that his surmise was a correct one.

The relationship of the Indian members is rather difficult to ascertain. The south Indian group of 77 species are closely connected with the 15 species from Ceylon, and has little or no relationship with the Himalayan group. Few of the central and lower Burma species of *Impatiens* have their allies in Siam and Malaya. It seems quite likely that the genus *Impatiens* is one of the very old plant groups of India, with three separate and independent centres of development as shown by the following map.

Celastraceæ:—Celastraceæ with 84 species in the Indian region are distributed in lower hills and plains of Continental India, Ceylon, Assam, Eastern Himalaya and Burma, with high concentration of species in South India and South Burma. The endemic figure for the family is 71 percent.

Some of the genera show high endemism such as *Euonymus* with 27 species endemic out of 32, bringing the endemic percentage to 84. The majority species of *Gymnosporia* are endemic in South India and the Eastern Himalaya. *Lophopetalum* and other genera occur both in Burma and South India—evidence of a definite link between the floras of these two regions. Except perhaps for *Euonymus* and *Celastrus* which are in temperate areas the relationship of the others seems strongly with Malayasian plants.

Papilionaceæ:—This is the largest family of Dicotyledons in India. The total number of species is as high as 867 including 372 'Wides'. The endemic percentage for the family is 57 percent.

The family embraces plants of varied habit and diverse tendencies. Thus species of *Dalbergia* with their lofty tree habit contrast strongly with the small herbaceous species found in the Himalayas.

In the Indian region genera like *Crotalaria* and *Tephrosia* have their greatest development in South India. *Millettia* has the strongest development in Assam and North Burma where as many as 16 species are found as endemics. *Caragana* and *Astragalus* on the other hand have developed strongly in the dry western Himalayas. The endemic percentage of *Astragalus* in the Himalayas is 75 and most of the species are found at high altitudes.

It seems clear from above that in India the genera of *Papilionaceæ* are distributed in very distinct areas and have developed freely there. This would suggest that the family has reached India from many sources and we find that its

associations tend to confirm this. The family affects chiefly the drier regions and there is usually a marked diminution when we come to areas of heavy rainfall. The Assam and the Burmese species show relationship with South-East Asia, the Himalayan with West and North Asia, while the South and West Indian species connect with the Orient and North Africa. This result is only to be expected.

Rosaceæ:—In India *Rosaceæ* are mainly distributed in the temperate regions of the Himalayas and other mountains. The total number of species is 257 which include 179 endemic species. The endemic percentage for the family is 70. Most of the species are found in alpine regions of the Himalayas. The distribution of species is rather poor in South India, Burma and the Indo-Gangetic plain.

As a family *Rosaceæ* undoubtedly belongs to the Northern Flora. A continuous distribution may be traced throughout Europe, the Orient, Northern and Western Asia, the Himalayas, North Burma and China. The representative genera of the north-western side are *Prunus*, *Rubus*, *Rosa*, *Potentilla*, *Cotoneaster* snd *Pyrus* while those of the eastern side are *Eriobotrya*, *Photinia*, and *Pygeum*.

Saxifragaceæ:—The most important genus in this family is *Saxifraga* the species of which are found chiefly in the temperate and alpine parts of the Eastern Himalayas. Of the 58 species of *Saxifraga* 51 are endemic, giving a percentage of 88 for the genus. Most of the species occur in the drier parts of Sikkim in the alpine regions adjoining the Tibetan frontier. The genus is not found in our area outside the Himalayas. The association of the Himalayan species is chiefly with the North and with China on the east.

The general endemic figure for the family is 76 percent. (87 species being endemic out of 114 species.)

The relationships of this family follow similar lines to those of the major northern groups showing the influence of temperate North and East Asia.

Rubiaceæ:—This is one of the largest families of Dicotyledons, and is well represented in Continental India, Burma, Assam and the subtemperate regions of the Himalayas. The main centre and development of this family for the area under review is undoubtedly in South India (and Ceylon) and Southern Burma. There are 551 species of *Rubiaceæ* in India of which 364 are endemics, thus bringing the percentage to 67. The majority of the 187 species of 'Wides' are found in Malayasia.

Six of the genera of *Rubiaceæ* are wholly endemic in the Indian region (see Appendix I) while others contain a high majority of endemics. The distribution of the leading genera in India is indicated below:—

Wendlandia—	19 sp.—13	endemic	4 in E. Himal. 5 in S. India. 1 in Burma.
Oldenlandia—	75 sp.—51	Do.	Mostly in Deccan.
Anotis—	17 sp.—15	Do.	5 in Assam and Trop. E. Himal. 10 in Deccan.
Ophiorrhiza—	36 sp.—31	Do.	17 in Assam and Himal. 9 in Deccan. 4 in Burma.
Ixora—	57 sp.—39	endemic	10 in Deccan. 25 in Burma.
Pavetta—	32 sp.—25	endemic	19 in Deccan. 4 in Burma.
Psychotria—	34 sp.—27	endemic	5 in Assam and Himal. 16 in S. India.

From the above it seems clear that the main concentration of *Rubiaceæ* is in South India and in the tropical rainforests of Assam and lower Burma. The genus *Ixora* has its best development in South Burma and this is balanced in South India by the many species of the allied genus *Pavetta*.

The Indian relationships of this family are strongly with the Malayasian flora.

Compositæ:—The family *Compositæ* with 696 species in India is one of the dominant groups of our flora but about half of the total number of species (330) has been found as 'Wides'. This brings down the endemic percentage to 52—a comparatively low figure. The distribution of species ranges from tropical region to the high alpines and in their specific content South India and the Himalayas are approximately equivalent. Burma is poor in its species of *Compositæ*. Some genera worthy of comment are as follows:—

(i) Saussurea—	41 species—37	endemic	All in Himalayas.
(ii) Aster—	20 sp.—15	endemic ..	All in Himalayas.
(iii) Senecio—	76 sp.—57	endemic ..	37 in Himalayas. 16 in S. India. 3 in Burma.
(iv) Anaphalis—	30 sp.—25	endemic ..	13 in Himalayas. 12 in S. India.
(v) Vernonia—	56 sp.—35	endemic ..	2 in Himalayas. 24 in S. India. 7 in Burma.
(vi) Centratherum—	8 sp.— 7	endemic	All in S. India.

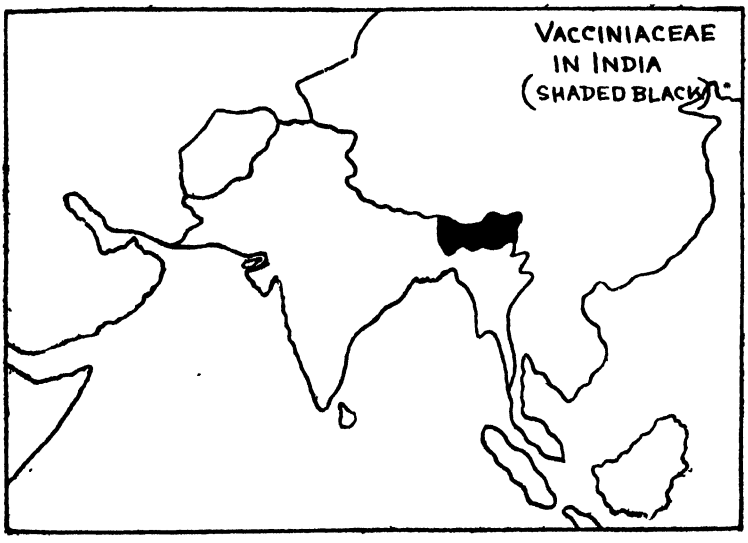
It will be evident from above that South India has a strong concentration of some temperate genera though it lacks the high alpines like *Aster* and *Saussurea*.

The association of the South Indian *Compositæ* is undoubtedly with the Orient and Africa and there is little evidence of

linkage with the Himalayas or with Burma. The intervening plains show few compositæ and these are chiefly 'Wides', and associated with cultivation. The Himalayan genera are in almost every case well-known constituents of the Northern Flora as found in North Asia and China.

The great adaptability of the seeds for dispersal has made it possible for the members of this family to be distributed through a very large area which explains the great number of 'Wides' in the flora.

The South Indian development is further emphasised by the occurrence of five endemic genera (see Appendix I), while specialisation in the Himalayas has given but one endemic genus.



MAP 10.

Vacciniaceæ:—The greatest development of this family in the Indian area is to be found in the Eastern Himalaya, Assam and Burma, 64 species are endemic out of a total of 68, which brings the endemic percentage to the remarkably high value of 94. The most important genus is *Agapetes*. The Indian and Burmese species are related to the species in West China and this is quite in conformity with the distribution of *Ericaceæ* of which family the *Vacciniaceæ* are usually regarded as an offshoot.

Ericaceæ:—The most important genus of this family is *Rhododendron*. The species of this genus are nearly always found in the temperate and alpine zones of the mountain regions

in our area. They are most abundant in the eastern Himalayas and are frequent in North Burma. They extend however to the N.W. Himalaya, to the Khasia and even to the Nilgiris. The total number of species in our record is 126 as compared with 43 described in the flora of British India. The main additions have come from Upper Burma and from Bhutan.

At one time the Himalaya was regarded as the chief centre of the genus, but recent exploration has shown that the Western Provinces of China contain the largest assemblage of species. The Indian species show a close affinity with the Chinese species although very few are common to both areas. The number of endemic species in the Himalayas is 64 and in Upper Burma 44. This gives a high endemic ratio of 90 percent, and this indicates that the species though closely allied to the Chinese ones are in most cases quite distinct.

Primulaceæ:—The two chief genera are *Primula* and *Androsace*, and these are confined in their distribution to the northern Hemisphere with one or two exceptions. In our area they occur chiefly in the Himalaya but have several representatives in Upper Burma and the Khasia Hills. It is clear from the analysis that *Primula* has the greatest development in the moister eastern Himalaya, while *Androsace* is more prominent in the dry north-west Himalayas. Of the two, much the largest is *Primula* with 162 species. Of these 148 are believed to be endemic and thus the percentage is the high figure of 91. As is the case with *Rhododendron*, the chief assemblage of species of this genus is to be found in the Western provinces of China, and the great majority of the Indian species find their nearest allies in the Chinese flora Evidence of this is readily given by such species as *P. capitata*. *P. denticulata* and *P. involucrata*. The species from the north west Himalayas indicate a certain degree of association with the northern Asia as suggested by such species like *P. sibirica* and *P. nivalis*. One or two species from the dry north-west Himalayas are closely linked with species in Persia, Arabia and Abyssinia. But there is no doubt that the main association is with the species of China and this is particularly true of the north Burmese plants which are nearly all concentrated near the Chinese border—most of them are Chinese plants which have crossed from China into the adjoining Burmese mountains. It may also be noted that in the Himalayas there are more species of *Primula* than any other area in the world except West China.

There is one interesting monotypic genus *Bryocarpum*—at one time presumed to be endemic in the eastern Himalayas, but it has recently been recorded from South-East Tibet. Another genus *Omphalogramma* has a restricted geographical range being found only in the eastern Himalayas with 2 species and also in the West China and Burma where there are some 6 additional species.

Asclepiadaceæ:—*Asclepiadaceæ* is a family represented in India chiefly from the Deccan Peninsula and the foothills of the Himalayas. The total number of species in our record is 234 of which 172 are endemic, thus bringing the endemic value to 73 percent. These species belong to 49 genera and so most of the genera can contain but few species. Of the genera 10 are found to be endemic.

Mention may be made of genera like *Caralluma*, *Hoya*, and *Ceropegia*. *Caralluma* is a genus of special interest as in our area it has developed in a marked degree only in the dry parts of the Deccan and western India. Of the 12 species all are endemic except 3 which are also found in the dry regions of Persia. The greatest development of the genus is in Africa and Madagascar—and here without any doubt the relationship of the Indian species is strongly with Africa (quite possibly via the Orient) and this is perhaps one of the very few examples of a definite African element in our flora.

Ceropegia has 40 species in India and this genus as a whole is also strongly developed in South India (where 26 species are found as endemic). Only 3 species are found in the subtropical regions of the Himalayas and 2 occur in Burma.

A contrasting genus for *Ceropegia* is perhaps *Hoya* where out of 30 species 22 are found as endemic in the Himalayas and Burma and only 3 in South India.

Such pairs of genera tend to counterbalance the general distribution of endemic species of a family. If we take the above particular genera and consider restricted areas the endemic index is naturally high but *Asclepiadaceæ* as a whole for the total area shows but a moderate degree of endemism (i.e. 73 percent).

Gesneriaceæ:—The members of this family which occur in Eastern Asia are remarkable for their very restricted distribution of the individual species. Only one or two have anything like a wide range. The species are found chiefly in the subtropical regions of the east Himalayas, Khasia Hills, Burma, and Malayasia. Most of the species occur at moderate elevations in the moister hills (3000 to 5000 feet). The only exception is perhaps species of *Didissandra* which are found at much higher altitudes.

The general endemic percentage for the family is 92, which is very high for a subtropical family and is in accord with the restricted specific range, already mentioned. Of a total of 133 species 122 are found endemic in the Indian area. About 100 species occur in East Himalaya, Assam and Burma and only 14 in the Nilgiris. The high endemicity is also emphasised by the presence of 7 endemic genera out of 27.

The relationship of the family is undoubtedly with Malayasia and it is quite possible that the Indian *Gesneraceæ* have come in great part from S.E. Asia.

Acanthaceæ:—The family Acanthaceæ contains a very large number of species in India (514). They occur chiefly in the tropical and subtropical regions of our area and are particularly abundant in the Deccan Peninsula where as many as 188 species are endemic.

The general endemic figure for the family is 82 percent which is very high for a tropical family. This high endemicity is readily seen in *Strobilanthes* where 146 species are endemic out of a total of 152. This is one of the largest genus in India. Other genera of interest are:—

(i) Staurogyne Wall.— 22 sp.—18 endemic	.. 1 Himalaya, 1 Continental India, 11 Burma
(ii) Stenosiphonium Nees. 5 sp.— 5 endemic	.. All in S. India
(iii) Barleria Linn— 24 sp.—16 endemic	.. 15 in S. India
(iv) Andrographis Wall— 23 sp.—18 endemic	.. All in S. India
(v) Phlogacanthus Nees— 10 sp.—10 endemic	.. 8 in Himalaya, 1 in S. India, 1 in Burma

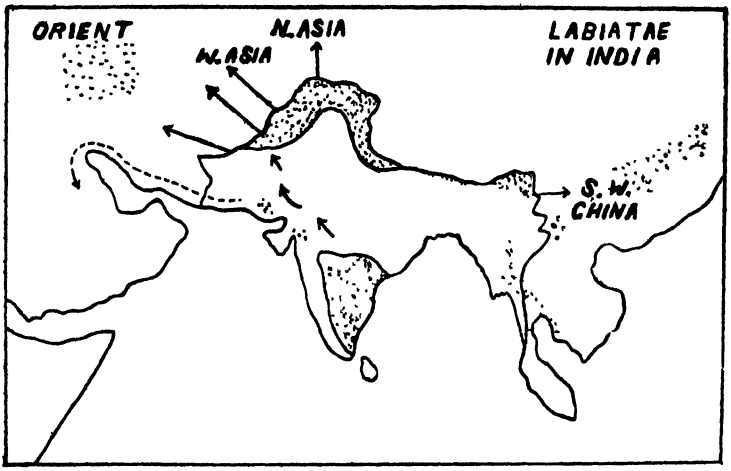
The number of endemic genera in India is 14, out of a total of 50. This suggests that India is probably one of the best regions for the development of Acanthaceæ.

Labiatæ:—The family *Labiatæ* is represented in India by 421 species in 69 genera. Of these 261 are endemic and the percentage is 62. The members of the *Labiatæ* inhabit comparatively dry areas and moderate altitudes. Very few species are found in the plains. Two centres of concentration of species may be found in our area and these are north-west India, and the Deccan. These two regions are linked through Sind and Beluchistan and the general relationship of these areas are to be found with the drier Orient and North-Western Asiatic flora. (shown by the diagram below).

The very moist parts of India contain but a few species and mention may be made of species of *Gomphostemma* and *Mesona*, found in Assam and North Burma. These can be linked with other species found in the eastern Himalayas—another area of heavy rainfall.

The South Indian development of *Labiatæ* is very remarkable and a possible parallel to such a strong concentration of a Northern family in this region is found in *Balsaminaceæ* (*Impatiens*). But *Balsaminaceæ* have developed in Malabar—the moist half of the Peninsula—while *Labiatæ* on the other hand have multiplied mostly in the eastern dry part—the Deccan.

The general endemic figure for the family seems to be rather low, but the endemicity is high in some of the genera shown in the following list:



MAP 11.

(*a*) Plectranthus—37 sp.—31 endemic	12 in Himalayas 12 in Cont. India 6 in Burma
(*b*) Anisochilus—14 sp.—12 endemic	2 in Himalayas 10 in Cont. India 7 in Himalayas
(*c*) Pogostemon—27 sp.—23 endemic	15 in Cont. India 1 in Burma
(*d*) Nepeta—42 sp.—26 endemic	25 in W. Himalayas 1 in Cont. India
(*e*) Leucas—42 sp.—28 endemic	24 in Cont. India 4 in Burma
(*f*) Elsholtzia—14 sp.—10 endemic	8 in Himalayas 2 in Burma
(*g*) Salvia—23 sp.—11 endemic	10 in Himalayas 1 in Burma
(*h*) Dracocephalum—9 sp.—7 endemic	All in Himalayas
(*i*) Phlomis—10 sp.—6 endemic	5 in Himalayas 1 in Burma
(*j*) Gomphostemma—22 sp.—16 endemic.	9 in Himalayas 2 in Cont. India 5 in Burma

It will be clear from the above that genera like (*b*), (*c*), (*e*), are strongly represented in the Continental India and conversely (*d*), (*f*), (*g*), (*h*), (*i*) in the Himalayas.

The relationship of the Indian Labiatæ is in the main with the species occurring in the Orient. A moderate influence from China and Malayasia is also responsible for some of the species in Assam and Burma.

Polygonaceæ:—A complete account of the Indian species of *Polygonum* has been made by Gage in *Rec. Bot. Surv. Ind. II. 5. (1903)*. This genus with 88 species in our area is by far the most important representative of the family. There are two striking facts about the species. The first is the high endemism shown by almost all the species found in the hills, and secondly the great range of altitude covered by some species. The member showing the greatest vertical range is *Polygonum viviparum* L. which is found from 5,000 to 18,000 feet. As a contrast other species such as *P. perpusillum* Hook. f. and *P. Hookeri* Meissn. have a very restricted range in the Himalayas.

78 species are endemic in India out of a total of 88 which brings the endemic value to 88 percent. The "wides" mostly come from the side of Persia and Afghanistan. The chief distribution of *Polygonum* is definitely in the dry regions of the Western Himalayas and other mountains and as we approach Burma and the S.E. Asia the species diminish rapidly in number.

Loranthaceæ:—This family of semi-parasitic plants are found distributed chiefly in the tropics of the whole world. The greatest development in the eastern Hemisphere has undoubtedly taken place in the Malayasian region where numerous species have been reported. Of the 73 species in the Indian region only 47 are found to be endemic which brings the percentage to 64. The species are mainly found in Malabar, and moist rain-forest of Assam. The association of these are to be found with the species from Malaya, Sumatra, Java and Borneo.

Euphorbiaceæ:—Owing to its wide distribution in the tropical and subtropical regions the family *Euphorbiaceæ* has a moderate endemicity in India—only 63 percent. The major concentration of species has taken place in the Deccan peninsula where they grow well in warm and dry localities. Burma and the Himalayas—both moist areas, are equivalent in their endemic contents and have comparatively few species.

The widespread and well characterised genus *Euphorbia* shows a strong representation in India where 41 species have been found to be endemic out of a total of 63. Here the number of species seems to be equally balanced between Continental India and the Himalayas. It is further interesting to note that in the Himalayas the species are found at high altitudes, even in the alpine zone and resemble the species of northern Asia. Most of the species of the Deccan and West India are fleshy like Cacti, and show therefore a relationship with those of the Orient and Africa.

The number of genera in our area is 70 and of these only five are endemic.

SUMMARY.

The present paper attempts to survey the nature of endemism among Indian Dicotyledons in a detailed manner, as similar work has not been previously done. The distribution, relationship and other features of interest in the Indian Species have been indicated in a commentary in the last section.

The total number of species is 11,124 (approximately), of which 61·5 percent is endemic and the rest 38·5 percent occur in our area as "wides". The endemic species have been found in high concentration in three regions, (*a*) the Himalayas, (*b*) South India, and (*c*) Burma.

A complete catalogue of the Indian Dicotyledons has been made showing the present distribution and modern nomenclatural changes for each species.

It was further necessary to modify the existing Phytogeographical map of India, previously made by Clarke (1898) and Hooker (1904). The modified arrangement is shown on page 25.

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APPENDIX I.

List of Endemic Genera from India and Burma.

PAPAVERACEÆ—

Cathcartia Hook. f. (Reduced to *Meconopsis*, Vig. by G. Taylor in his monograph. 1934.)	E. Himalaya.

CRUCIFERÆ—

Lepidostemon Hook. f. and T. ..	E. Himalaya (Sikkim).
Arcyosperma Schultz	E. and W. Himalaya.
Douepia Camb.	S. W. Punjab.

CAPPARIDACEÆ—

Hypselandra Pax et Hoffmann (Fedde Repert. XLI (1936) 128).	Burma.
Borthwickia W. W. Smith. (Trans. Proc. Bot. Soc. Edin. XXIV (1911) 175.	Burma (Upper).

FLACOURTIACEÆ—

Gynocardia R. Br.	E. Himalaya, Assam, Burma, Chittagong.

GUTTIFERÆ—

Poecilonеuron Bedd.	S. India (Malabar).

MALVACEÆ—

Decaschistia W. and A.	S. India.

STERCULIACEÆ—

Mansonia Drumm.	Burma (Lower).

TILIACEÆ—

Erinocarpus Nimmo.	S. India.
Plagiopteron Griff.	Burma (Lower).

LINACEÆ—

Anisadenia Wall.	C. and E. Himalaya, Khasia. Now found in extreme South China.

RUTACEÆ—

Chloroxylon DC.	S. India (Nilgiri, Ceylon).

MELIACEÆ—

Beddomea Hook. f.	S. India (Malabar).

SAPINDACEÆ—

Otonephelium Radlk.	S. India (Malabar).
Zollingeria Kurz	Burma (Lower).

ANACARDIACEÆ—

Solenocarpus W. and A.	S. India (Malabar).
Drimycarpus Hook. f.	E. Himalaya (Sikkim), Khasia.
Nothopegia Bl.	S. India (Malabar, Ceylon).

PAPILIONACEÆ—

Stracheya Benth.	C. Himalaya, Tibet.
Neocollettia Hemsl.	Burma.
Ougeinia Benth.	W. Himalaya, S.W. Punjab.
Dicerma DC.	Burma.
Phyllodium Desv.	Burma.
Cateneria Benth.	Burma.
Cochlianthus Benth.	C. Himalaya.
✓*Butea* (Roal) Koen.	India, Burma.
Mastersia Benth.	E. Himalaya (Mishmi, Hills).

CÆSALPINACEÆ—

Wagatea Dalz.	S. India (Malabar).

RHIZOPHORACEÆ—

Blepharistemma Wall.	S. India (Malabar).

MYRTACEÆ—

Meleoromyrtus, Gamble	S. India (Malabar).

CUCURBITACEÆ—

Biswarea Cogn. (Syn. ***Warea*** **Clarke**)	E. Himalaya (Sikkim).
Dicœlosperma Clarke	S. India (Malabar).
Edgaria Clarke	E. and W. Himalaya.

UMBELLIFERÆ—

Vicatia DC.	E. and W. Himalaya.
Meeboldia Wolff.	W. Himalaya.
Polyzygus Dalz.	S. India (Malabar).
Pleurospermopsis Norman	E. Himalaya (Sikkim).
Cortia DC.	E. and W. Himalaya.

ARALIACEÆ—

✓*Pentapanax* Seem.	India.
Woodburnia Prain	Burma.
Gamblea Clarke	E. Himalaya (Sikkim).
Tupidanthus Hook. f.	Khasia.

CORNACEÆ—

Torricella DC.	E. and W. Himalaya.

CAPRIFOLIACEÆ—

Pentapyxis Hook. f.	E. Himalaya (Sikkim).

RUBIACEÆ—

Clarkella Hook. f.	W. Himalaya.
Polyura Hook. f.	Khasia, E. Himalaya (Mishmi).
Parophiorrhiza Clarke	Khasia.
Carlemannia Benth.	E. Himalaya (Sikkim), Khasia.
Silvianthus Hook. f.	Khasia, (Sylhet).
Octotropis Bedd.	S. India (Malabar).

VALERIANACEÆ—

Nardostachys DC.	E. and W. Himalaya. Also recently recorded from South China.

COMPOSITÆ—

Lamprachænium Benth.	S. India (Malabar).
Adenoon Dalz.	S. India (Malabar).
Nanothamnus Thoms.	S. India (Malabar).
Cæsulia Roxb.	Punjab, Chittagong, Deccan.
Glossocardia Cass.	C. India, and S. India.
Goniocaulon Cass.	C. India and S. India.
Catamixis Thoms.	W. Himalaya.

CAMPANULACEÆ—

Leptocodon Hook. f. and T.	E. Himalaya. Now recorded from South China.

VACCINIACEÆ—

Pentapterygium Klotzsch	E. Himalaya (Sikkim) Khasia.
Corallobotrys Hook. f.	Khasia, E. Himalaya (Bhutan).

ERICACEÆ—

Diplarche Hook. f. and T.	E. Himalaya (Sikkim).

PYROLACEÆ—

Cheilotheca Hook. f.	Khasia.

PRIMULACEÆ—

Bryocarpum Hook. f. and T. ..	E. Himalaya (Sikkim to Mishmi).

MYRSINACEÆ—

Sadiria Mez.	E. Himalaya (Bhutan), Khasia.
Antistrophe A.DC.	S. India (Malabar, 1 sp.), Khasia (1 sp.)
Hymenandra A. DC.	Assam.
Amblyanthus A. DC.	Khasia.
Amblyanthopsis Mez.	E. Himalaya (Bhutan), Assam.

STYRACACEÆ—

Parastyrax W. W. Smith	Burma (Upper).

ASCLEPIADACEÆ—

Brachylepsis W. and A.	S. India (Nilgiri).
Utleria Bedd.	S. India (Deccan).
Decalepsis W. and A.	S. India (Deccan).
Pentabothra Hook. f.	Assam (Kamrup).
Adelostemma Hook. f.	Burma.
Lygisma Hook. f.	Burma.
Treutlera Hook. f.	E. Himalaya (Sikkim).
Dittoceras Hook. f.	E. Himalaya (Sikkim).
Oianthus Benth.	S. India (Deccan).
Frerea Dalz.	S. India (Malabar).

GENTIANACEÆ—

Parajæschkea Burkill.	E. Himalaya (Sikkim).
Jæschkea Kurz.	E. and W. Himalaya. Now recorded from S. China.

BORAGINACEÆ—

Lacaita Brand.	E. Himalaya (Sikkim), Burma (Upper).
Actinocarya Benth.	E. and W. Himalaya, Tibet.
Microula Benth.	Himalaya and Tibet.

CONVOLVULACEÆ—

Blinkworthia Choisy.	Burma.

SCROPHULARIACEÆ—

Bythophyton Hook. f.	Khasia.
Hemiphragma Wall.	E. Himalaya, Khasia, Burma. Now recorded from S. China.
Picrorhiza Royle	E. and W. Himalaya.
Oreosolen Hook. f.	E. Himalaya (Sikkim).
Falconeria Hook. f.	W. Himalaya.

GESNERACEÆ—

Platystemma Wall.	W. Himalaya.
Boeica Clarke	E. Himalaya, Burma (Upper).
Tetraphyllum Griff.	Assam and Chittagong.
Trisepalum Clarke	Burma (Lower).
Phylloboea Clarke	Burma (Lower).
Jerdonia Wight	S. India (Deccan).
Leptoboea Benth.	E. Himalaya (Sikkim, Mishmi Hills), Khasia.

ACANTHACEÆ—

Ophiorrhizophyllon Kurz.	Burma (Lower).
Meyenia Nees.	S. India (Deccan).
Petalidium Nees.	S.W. Punjab and S. India.
Aechmanthera Nees.	E. and W. Himalaya.
Stenosiphonium Nees.	S. India
Calacanthus Anders.	S. India (Malabar).
Phlogacanthus Nees.	Himalaya, Assam, Burma.
Diotacanthus Benth.	S. India (Malabar).
Cystacanthus Anders.	Burma.
Haplanthus Nees.	S. India (Malabar), Burma.
Asystasiella Lindau	Khasia.
Philacanthus Benth.	N. Assam.
Odontonemella Lindau	Khasia.
Sphinctacanthus Benth.	Assam.

LABIATÆ—

Craniotome Reich.	E. and W. Himalaya, Khasia.
Eriophyton Benth.	E. and W. Himalaya.
Roylea Wall.	W. Himalaya.
Notochæte Benth.	E. Himalaya, Burma.

AMARANTACEÆ—

Banalia Moq.	S. India.
Stilbanthus Hook. f.	E. Himalaya (Sikkim), Khasia.

PODOSTEMACEÆ—

Griffithella Warming		S. India (Malabar).
Willisia Warming		S. India (Nilgiri).

CYTINACEÆ—

Sapria Griff.	..	E. Himalaya (Mishmi Hills).

LAURACEÆ—

Syndichis Hook. f.		E. Himalaya (Bhutan).
Purkayasthea Purkayastha		Khasia.
Dodecadenia Nees.		Himalaya, Assam, Burma.

LORANTHACEÆ—

Helicanthes Danser		S. India.

SANTALACEÆ—

Phacellaria Benth.		Manipur and S. Burma.

EUPHORBIACEÆ—

Pseudoglochidion Gamble		S. India (Malabar).
Neopeltandra Gamble		S. India (Malabar).
Prosorus Dalz. ..		S. India (Malabar).
Platystigma R.Br.		Assam.
Lasiococca Hook. f.		E. Himalaya (Sikkim).

Appendix II

Table showing the numbers of Endemic and Non-Endemic Species of Indian Dicotyledons in each family.

	Total No. Sp.	Total No. Gen.	Wides.	Endemics.			
				Cont. I.	Himalayas.	Burma.	G. Area.
Ranunculaceæ ..	162	21	61	13	80	5	3
Dilleniaceæ ..	15	3	10	3	0	1	1
Magnoliaceæ ..	36	7	5	0	24	6	1
Schizandraceæ ..	5	2	4	0	1	0	0
Anonaceæ ..	129	22	52	28	11	29	9
Menispermaceæ ..	42	17	30	6	4	1	1
Lardizabalaceæ ..	5	4	1	0	4	0	0
Berberidaceæ ..	35	4	1	1	28	3	2
Nymphæaceæ ..	11	6	7	3	0	0	0
Cruciferæ ..	174	43	78	8	86	0	2
Fumariaceæ ..	66	4	18	0	47	1	1
Papaveraceæ ..	43	7	15	0	25	3	0
Capparidaceæ ..	65	10	30	18	2	12	3
Resedaceæ ..	4	3	4	0	0	0	0
Violaceæ ..	25	3	14	1	7	3	0
Bixaceæ ..	1	1	1	0	0	0	0
Cochlospermaceæ ..	1	1	1	0	0	0	0
Flacourtiaceæ ..	21	5	10	4	1	3	3
Pittosporaceæ ..	8	1	4	2	2	0	0
Polygalaceæ ..	32	4	25	4	1	2	0
Xanthophyllaceæ ..	7	1	5	1	1	0	0
Frankeniaceæ ..	1	1	1	0	0	0	0
Caryophyllaceæ ..	107	18	44	2	57	1	3
Portulacaceæ ..	6	2	5	1	0	0	0
Tamariscaceæ ..	8	2	4	2	1	0	1
Elatinaceæ ..	6	2	5	1	0	0	0
Hypericaceæ .	26	3	11	1	11	1	2
Guttiferæ ..	40	6	20	13	3	4	0
Ternstroemiaceæ ..	39	13	18	8	7	4	2
Dipterocarpaceæ ..	51	8	16	15	2	17	1
Ancistrocladaceæ ..	5	1	4	1	0	0	0
Malvaceæ ..	111	22	81	18	4	6	2
Sterculiaceæ ..	80	19	47	18	9	5	1
Tiliaceæ ..	78	9	42	21	4	6	4
Elæocarpaceæ ..	42	2	27	4	7	3	1
Linaceæ ..	8	5	5	0	3	0	0
Erythroxylaceæ ..	6	1	5	0	1	0	0
Malpighiaceæ ..	17	2	10	2	4	0	1
Zygophyllaceæ ..	9	5	9	0	0	0	0
Geraniaceæ ..	28	4	16	0	11	0	1
Oxalidaceæ ..	14	3	9	3	2	0	0
Balsaminaceæ ..	242	2	21	77	112	26	6
Rutaceæ ..	71	24	48	9	7	5	2
Simarubaceæ ..	15	7	11	1	3	0	0
Ochnaceæ ..	9	2	5	3	0	1	0
Burseraceæ ..	13	5	3	9	0	0	1
Meliaceæ ..	62	19	27	17	11	4	3
Dichapetalaceæ ..	3	1	3	0	0	0	0
Olacaceæ ..	18	6	13	2	2	0	1

APPENDIX II—*contd.*

	Total No. Sp.	Total No. Gen.	Wides.	ENDEMICS.			
				Cont. I.	Himalayas.	Burma.	G. Area.
Icacinaceæ	25	12	7	10	2	5	1
Opiliaceæ	4	3	3	0	0	1	0
Aquifoliaceæ	34	1	21	3	4	4	2
Celastraceæ	84	10	24	22	22	10	6
Hippocrateaceæ	27	3	13	6	5	2	1
Rhamnaceæ	53	11	25	10	15	2	1
Ampelidaceæ	70	8	31	18	13	1	7
Leeaceæ	27	1	6	5	3	3	10
Staphyleaceæ	4	2	3	1	0	0	0
Hippocastanaceæ	2	1	2	0	0	0	0
Sapindaceæ	54	20	34	7	3	8	2
Aceraceæ	20	1	3	0	15	2	0
Sabiaceæ	19	2	5	1	10	1	2
Anacardiaceæ	67	20	25	20	8	9	5
Coriariaceæ	1	1	1	0	0	0	0
Connaraceæ	20	5	11	3	1	4	1
Papilionaceæ	862	112	372	176	147	108	59
Cæsalpiniaceæ	125	23	78	21	5	15	6
Mimosaceæ	96	17	53	26	6	9	2
Rosaceæ	255	26	76	14	144	11	10
Saxifragaceæ	114	17	27	0	83	4	0
Crassulaceæ	64	7	15	4	44	1	0
Droseraceæ	4	2	4	0	0	0	0
Hamamelidaceæ	7	7	3	0	4	0	0
Halorrhagidaceæ	14	5	10	3	0	0	1
Rhizophoraceæ	16	9	15	1	0	0	0
Combretaceæ	49	6	26	11	1	9	2
Hernandiaceæ	4	2	2	2	0	0	0
Myrtaceæ	116	9	59	44	4	4	5
Lecythidaceæ	12	2	7	1	0	4	0
Melastomaceæ	127	16	42	48	16	17	4
Lythraceæ	48	7	26	15	2	4	1
Crypteroniaceæ	3	1	1	0	1	1	0
Sonneratiaceæ	5	2	4	0	0	0	1
Onagraceæ	39	6	13	2	24	0	0
Samydaceæ	20	2	9	5	2	1	3
Passifloraceæ	7	2	4	0	3	0	0
Caricaceæ	1	1	1	0	0	0	0
Turneraceæ	1	1	1	0	0	0	0
Cucurbitaceæ	86	28	58	12	9	2	5
Begoniaceæ	71	1	16	7	26	18	4
Dasticaceæ	2	2	2	0	0	0	0
Cactaceæ	6	3	6	0	0	0	0
Aizoaceæ	16	7	16	0	0	0	0
Umbelliferæ	180	43	49	23	101	4	3
Araliaceæ	55	15	23	7	20	4	1
Alangiaceæ	6	1	4	0	1	1	0
Cornaceæ	12	5	8	1	3	0	0
Nyssaceæ	2	1	1	0	0	1	0
Caprifoliaceæ	56	8	13	2	39	0	2
Rubiaceæ	555	68	187	170	101	66	31
Valerianaceæ	20	4	4	6	10	0	0

APPENDIX II—*contd.*

	Total No. Sp.	Total No. Gen.	Wides.	ENDEMICS.			
				Cont. I.	Himalayas.	Burma.	G. Area.
Dipsaceæ ..	17	4	3	1	12	1	0
Compositæ ..	697	126	330	102	219	23	23
Stylidaceæ ..	3	1	3	0	0	0	0
Goodeniaceæ ..	2	1	2	0	0	0	0
Campanulaceæ ..	71	13	24	4	38	4	1
Vacciniaceæ ..	68	4	4	1	39	21	3
Ericaceæ ..	144	9	18	0	78	44	4
Monotropaceæ ..	3	3	2	0	1	0	0
Diapensiaceæ ..	1	1	0	0	1	0	0
Plumbaginaceæ ..	8	6	5	2	1	0	0
Primulaceæ ..	208	7	31	2	159	16	0
Myrsinaceæ ..	92	10	29	12	37	9	5
Sapotaceæ ..	32	10	14	10	4	3	1
Ebenaceæ ..	58	2	18	18	11	10	1
Symplocaceæ ..	51	1	7	23	14	6	1
Styracaceæ ..	9	3	3	0	3	3	0
Oleaceæ ..	97	10	29	25	23	16	4
Salvadoraceæ ..	5	3	5	0	0	0	0
Apocynaceæ ..	84	36	30	17	14	17	6
Asclepiadaceæ ..	232	49	62	73	61	19	17
Loganiaceæ ..	40	8	20	3	9	3	5
Gentianaceæ ..	188	15	42	24	89	28	5
Menyanthaceæ ..	1	1	1	0	0	0	0
Polemoniaceæ ..	1	1	1	0	0	0	0
Hydrophyllaceæ ..	1	1	1	0	0	0	0
Boraginaceæ ..	145	39	62	27	47	4	5
Convolvulaceæ ..	177	24	90	43	12	20	12
Solanaceæ ..	58	14	42	7	6	0	3
Scrophulariaceæ ..	274	54	135	22	90	16	11
Orobanchaceæ ..	29	7	17	5	6	1	0
Lentibulariaceæ ..	30	2	13	9	5	3	0
Gesneriaceæ ..	133	27	11	14	66	34	8
Bignoniaceæ ..	32	13	16	5	2	7	2
Pedaliaceæ ..	4	2	2	2	0	0	0
Acanthaceæ ..	508	50	88	188	107	99	26
Verbenaceæ ..	115	15	60	18	18	8	11
Labiatæ ..	419	69	160	81	110	28	40
Plantaginaceæ ..	13	1	12	0	1	0	0
Nyctaginaceæ ..	8	3	4	2	1	0	1
Illecebraceæ ..	2	2	2	0	0	0	0
Amarantaceæ ..	47	17	31	9	4	1	2
Chenopodiaceæ ..	40	18	37	2	1	0	0
Phytolaccaceæ ..	2	2	2	0	0	0	0
Polygonaceæ ..	110	8	25	3	64	1	17
Podostemaceæ ..	16	8	5	9	1	0	1
Nepenthaceæ ..	1	1	0	0	1	0	0
Cytinaceæ ..	1	1	0	0	1	0	0
Aristolochiaceæ ..	13	3	4	3	5	1	0
Piperaceæ ..	103	4	15	24	52	8	4
Chloranthaceæ ..	3	2	3	0	0	0	0
Myristicaceæ ..	14	4	5	6	1	0	2
Lauraceæ ..	171	18	33	45	63	19	11

APPENDIX II—*concld.*

	Total No. Sp.	Total No. Gen.	Wides.	ENDEMICS.			
				Cont. I.	Himalayas.	Burma.	G. Area.
Hernandiaceæ ..	1	1	1	0	0	0	0
Proteaceæ ..	7	1	2	2	0	2	1
Thymeleaceæ ..	22	10	12	0	7	0	3
Elæagnaceæ ..	12	2	4	5	3	0	0
Loranthaceæ ..	73	13	26	24	11	9	3
Santalaceæ ..	15	7	3	3	4	4	1
Balanophoraceæ ..	6	2	1	0	4	0	1
Buxaceæ ..	6	2	2	1	2	1	0
Euphorbiaceæ ..	442	70	161	119	74	68	20
Ulmaceæ .	16	5	10	1	1	2	2
Cannabinaceæ ..	2	2	2	0	0	0	0
Moraceæ ..	114	15	70	10	14	8	12
Urticaceæ ..	111	20	42	10	43	7	9
Platanaceæ ..	1	1	1	0	0	0	0
Juglandaceæ ..	4	2	4	0	0	0	0
Myricaceæ ..	1	1	1	0	0	0	0
Casurinaceæ ..	1	1	1	0	0	0	0
Cupuliferæ ..	64	7	22	2	19	9	12
Salicaceæ ..	43	2	14	0	28	0	1
Ceratophyllaceæ ..	1	1	1	0	0	0	0

REVIEWS OF BOOKS

THE NATIVE RACES OF AMERICA—COMPILED BY ROBERT ANGUS DOWNIE FROM THE MANUSCRIPT NOTE-BOOKS OF SIR J. G. FRAZER, O.M., F.R.S., F.B.A.—London, 1939. Price 35*s*.

This is the fourth and concluding volume of *Anthologia Anthropologica* prepared very carefully and accurately by R. A. Downie from the manuscript note-books of Sir J. G. Frazer. The earlier three volumes dealt with the races of Europe, Asia and Africa and Australasia.

The idea of publishing the contents of the notes taken by Sir J. G. Frazer from first-hand accounts of the native races of the world and in many cases from European visitors who were the first to describe their rituals and beliefs—was due entirely to the enterprise of Lady Frazer to whom science is indebted for her self-sacrificing devotion (for a considerable part of the cost of publishing had to be borne from her own private resources) for making her distinguished husband's manuscript notes taken during a period of fifty years and more, available to students of Anthropology.

Mr. Downie is responsible for arranging these notes geographically and thereby enhancing their scientific and practical value. The present volume is divided into three books—the first dealing with the races of Greenland and North America, the second and the third with those of Central and South America.

In these sections, extracts from all the main sources of our information on the American races, both American and European, including such men as Boas, Nelson, Swanton, Father Morice, Dorsey, Le Beau, Washington Mathews, de Nagera, de Oviedo, de Herrera, Alcide D'orbigny, von den Steinen, and P. Guevara, etc. are published together with English translations of passages from Father Arriaga's old Spanish book *Extirpacion de la Idolatria del Peru*.

It is needless to say that most of these source books, specially those dealing with Central and South America are difficult to obtain and students of Anthropology, specially those on America, will find it very useful for their studies.

The whole series is beautifully printed and the price is not excessive considering the size and get up of the volumes.

B. G.

Journal Royal Asiatic Society of Bengal. Science.

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ARTICLE No. 4.

Mother and Child combinations of Blood Groups and Blood Types and their development in Bengalis.

By EILEEN W. E. MACFARLANE.

An opportunity arose early in 1939 to obtain cord blood and mother's blood from hospital patients in Calcutta. This investigation involved testing the blood of Bengalis for groups, types and the relative development of agglutinogens and agglutinins at birth. The data should be of some value to medico-legal work as confirmatory to inheritance studies on blood groups and types.

METHODS AND MATERIAL.

At the time of delivery an ounce or so of cord blood from each infant was placed in a labelled sterile bottle by the hospital authorities. It was then put in a refrigerator. Each morning all cord blood samples from deliveries in the previous twenty-four hours were sent to me, except on Sundays. A day or two after delivery some blood from each mother was also sent. As soon as a sample was received the serum was poured off and the red blood cells were obtained from the fresh clot by shaking up with normal saline. The suspensions of cells were centrifuged in graduated test-tubes and a 2% suspension of each was made.

The blood cells were usually grouped and typed at once and only occasionally were they left in the refrigerator overnight. Most of the samples were between 12 and 36 hours old when tested. There was no indication that the cells lost sensitivity to agglutination, as suggested by some workers, even after 36 hours (Table I), nor that irregular, abnormal agglutinations occurred.

The technique adopted throughout was that of Greval (Greval *et al.*). His calibrated capillary finger pipettes were found very satisfactory . The open slide method was therefore used together with moist chambers made from Petrie dishes large enough to hold 4 or 5 slides, as described by Greval. These allow easy rotation of the spots of fluids on the contained slides and delay desiccation for hours.

In testing for agglutinogens one drop of standard test serum was mixed with one drop of the 2% cell suspension. Tests for both A and B (or M and N) were made on the same slide with a glass pencil line separating the two spots of liquid. As soon as four slides were set up in a Petrie dish they were gently rotated

and watched for incipient agglutination with a reading glass. The time in which a weak positive reaction could be detected was noted and subsequently the slides were examined every five minutes for 30–40 minutes. It was found, by checking under the microscope at first, that reactions classified as 'trace' (with clumps of 3 or 4 cells) and as 'plus-minus' (with clumps of 6–10 cells) according to Landsteiner and Levine (1929) and Taylor (1939) could be detected with the naked eye or reading glass when daylight was falling obliquely on the red blood cells while the slides were gently rotated. The aim has been to develop a simple technique that can be confidently used under difficult field conditions in India.

TABLE I.

Proportions of blood samples of different ages showing no agglutination (Group O) and agglutination with both test sera (Group AB).

Age of Babies' Cells in Hours.												
12–24 hrs.			24–48 hrs.			48–72 hrs.			Over 72 hrs.			
Total No.	Groups		Total No.	Groups		Total No.	Groups		Total No.	Groups		
	O	AB		O	AB		O	AB		O	AB	
128	46	13	74	26	4	40	16	4	18	5	3	

24–48 hrs.					48 hrs. and over.				
Total No.	Groups				Total No.	Groups			
	O	O%	AB	AB%		O	O%	AB	AB%
202	72	35·6	17	8·4	58	21	36·2	7	12

Testing for agglutinins in infants' sera, it was found more satisfactory to use two drops of the unknown serum to one drop of 2% suspension of known A or B cells. Among adults no anomalous blood, lacking the normal constituent agglutinin or agglutinins, has been found in Calcutta. All blood samples were first grouped and then typed when anti-fluids were available. Sera were often tested while the cell suspensions were being prepared.

TESTING MEDIA.

For grouping the cell suspensions test sera that had been checked against three different lots of standard cells were used. Only sera with a titre of 1 in 5, or more, were employed. The test sera were checked each day before beginning work with 2% suspensions of standard cells. These same cell suspensions were used for testing for agglutinins in the unknown sera.

Anti-M and anti-N fluids were prepared by the technique described by Greval (1939). It was again found more easy to obtain strong anti-ON sera than anti-OM, although the N tends to be removed during the absorption of the O. Standard cells of types M and N were obtained through the laboratory of the Imperial Serologist for testing the anti-sera, titrating the anti-fluids and checking results obtained with unknown cells. After typing with locally prepared fluids the bloods were frequently checked by means of some European commercial anti-fluids.

Group A and Group AB cells were tested for A_1 and A_2 sub-groups. The cells were centrifuged in a quill tube, twice their volume of Group B serum was added and the tube placed on its side in a moist chamber. After 30 minutes at room temperature and 30 minutes in a refrigerator the mixture was left outside for a further 30 minutes and then centrifuged. A drop of the supernatant fluid (agglutinin α') was mixed with a drop of (i) the original cell suspension, and (ii) known A_1 cells. If agglutination was obtained with both then absorption had been incomplete; if with A_1 only the specimen contained A_2; if it reacted with neither the original cells were A_1. As the work proceeded some stock α' serum was prepared by absorption with the cells of two Group A_2 mothers.

Sizes of Samples.

Cord bloods from 342 infants were grouped as well as the bloods of 361 mothers. Since an infant's blood and that of its mother were usually grouped on different days, the desired pairs were not always obtained for various reasons. Eventually 252 matching pairs of mothers and infants were grouped, mostly Bengalis of Brahmin, Kayastha and Muslim communities.

A total of 234 cord bloods were tested for agglutinins and 190 matching pairs of bloods were tested for both agglutinogens and agglutinins.

Because of the delay consequent upon preparing anti-M and anti-N fluids these were not always available during this investigation. A total of 103 matching pairs of mothers and babies was typed for M and N. Altogether 120 mothers and 114 babies were typed.

Agglutinogens at Birth.

Among 252 matching pairs of mothers and babies at birth, 127 were found to be homospecific for blood group and 125 heterospecific. Throughout this investigation it was noticeable that 50% of the babies had their mothers' blood group. This relationship holds fairly closely for all groups except Group AB mothers (see Table XI). Among Europeans in the United States only about 25% of women in Groups O, A and AB have

babies belonging to their own groups according to Wiener's table (1935, p. 18), although over 50% of Group B women have Group B children.

This relationship depends, of course, on the frequencies of the three blood group genes in any population. These differ somewhat in the various Indian endogamous communities (Macfarlane, 1938). Eventually tables will be constructed for medico-legal use giving the chances for excluding paternity of a man of any given blood group for some of the largest communities, as has been done already in some western countries.

The agglutination time for babies' red blood cells was noticeably longer on the average than for their mothers, particularly for Group A. Each specimen was timed from the addition of the test sera until the appearance of a distinguishable weak agglutination. The clumps of agglutinated cells finally exert a repelling force on each other and are all pushed towards the periphery of the liquid in which they lie. The appearance of this repulsion was watched for every five minutes and recorded as a 'completed reaction'. Reaction times for fifty mothers and fifty babies in Group A_1 are classified according to speed of initiation and of completion in Table II. With mothers' cells the reaction starts, on the average within 2 minutes and is completed in 12·4 minutes. The average reaction with babies' cells starts in just after 3 minutes and takes 23·9 minutes to be completed. The non-agglutinated residue of cells in the babies' samples was also noticeably larger than in the mothers' bloods. This confirms findings among babies of other races that the agglutinogens have not attained full development at birth.

TABLE II.

Agglutinogen A reaction times in bloods of 50 mothers and 50 babies at birth.

Weak Reaction noted.			Reaction completed.		
Mins.	Nos. of Individuals.		Mins.	Nos. of Individuals.	
	Mothers.	Babies.		Mothers.	Babies.
1	21	11	3	7	1
2	19	28	5	5	2
3	6	7	10	20	11
4	1	1	15	13	5
5	2	0	20	0	9
10	1	0	30	4	20
15	0	1	60	1	2
20	0	2			
Average time in mins. ..	2·0	3·1		12·4	23·9

In Group B babies the agglutinogen is nearer adult strength at birth. Among fifty mothers in Group B agglutination began in 2·5 minutes and was completed in 13·5 minutes as shown in Table III. With fifty Group B infants reaction began, on an average, in 2·1 minutes and was completed in 15·8 minutes. Thus there is no significant difference perceptible in this group by the method employed, although more Group B babies than Group B mothers gave incomplete reactions (Table IV).

TABLE III.

Agglutinogen reaction times in bloods of 50 mothers and 50 babies at birth in Group B.

Weak Reaction noted.			Reaction completed.		
Mins.	Nos. of Individuals.		Mins.	Nos. of Individuals.	
	Mothers.	Babies.		Mothers.	Babies.
1	3	6	3	1	0
2	30	33	5	5	7
3	13	10	10	21	15
4	2	1	15	21	15
5	2	0	20	0	3
			30	0	8
			40	0	2
			60	2	0
Average time in mins. ..	2·5	2·1		13·5	15·8

TABLE IV.

Percentages of Slow and Weak Agglutinogens in Tables II and III.

	GROUP A		GROUP B	
	Mothers.	Babies.	Mothers.	Babies.
Slow (4 mins. and more) ..	8	8	8	2
Weak (incom. 20 mins. or more)	10	44	4	20

This differential development of the two agglutinogens may partly account for the impression that B is stronger in Group AB

children than A (Wiener). It is shown in Table IV that weak agglutination was found in only 4% of Group B mothers, but in 10% of Group A mothers. Only 20% of Group B babies showed weak agglutinogen compared with 44% of Group A babies. Samples of fifty only in each class were available, but the differences are large enough to be of interest and should be investigated further.

There are indications that agglutinogen sensitivity (particularly where A_1 is concerned) is inherited. The agglutination reactions of four A_1B children of A_1B mothers are shown in Table V. Mother number 84 passed on her weak A_1 and mothers 103 and 268 seem to have passed on their strong A_1 agglutinogen. The AB child of mother 84 possessed the weakest B agglutinogen for a full-term child found throughout this investigation.

TABLE V.

Agglutination reaction times in minutes in Group AB mothers and their AB babies.

Serial No.	Mother.				Baby.			
	Reaction starts.		Reaction complete.		Reaction starts.		Reaction complete.	
	A	B	A	B	A	B	A	B
58	3	3	15	15	3	3	incom.	15
84	3	1	30	15	5	5	incom.	incom.
103	2	2	10	10	2	2	7	30
268	1	1	10	10	1	1	10	10

The masking effect of B in Group AB when the sensitivity of A is low has been reported (Wiener). Among 20 mothers of Group AB, 10 showed reactions of equal strength for both agglutinogens, 8 had a higher sensitivity of A and only 2 had stronger B. Among 25 Group AB babies, 9 showed A equally as strong as B, 9 had stronger A and 7 had stronger B. In these small samples over three times as many babies as mothers have stronger B. This, however, is chiefly due to the greater sensitivity of agglutinogen B at birth as shown above. The reaction times of agglutinogen A in 30 homospecific pairs are given in Table VI. If the average reaction times shown in Tables II and III are taken into consideration, then 23 of these pairs have reactions of approximately equal strength. Two babies have actually faster reactions than their mother and three are comparatively faster. Of four mothers with very weak A_1 two have babies with fast A_1 and two have babies with slow A_1.

TABLE VI.

Reaction times in minutes of agglutinogen A in 30 homospecific pairs.

Serial No.	Mother.	Baby.	REMARKS.
20*	5–15	5–30	Both very slow.
43	3–15	3–20	
45	3–15	4–15	
83	2–10	3–30	Baby slower.
113	2–10	2–10	
124	2–10	20–60	Baby very slow.
141	2–15	2–30	
142*	5–30	2–30	Baby faster, mother very slow.
146	2–15	2–30	
150*	3–30	2–30	Baby average, mother slow.
172	1–10	2–20	
186	1–3	1–5	Both very fast.
188	1–3	2–10	
192	1–3	2–30	
211*	4–15	4–20	Both slow.
240	1–10	1–10	Both very fast.
242	1–10	2–30	
249	1–10	2–10	Both fast.
262	1–15	2–30	
276	2–10	2–10	
295	1–20	2–30	
300	1–10	1–15	Both very fast.
306	1–7	1–7	,, ,, ,,
326	1–15	2–30	
328	1–2	2–20	
329	2–30	2–30	Mother a bit slow.
331	2–30	2–30	,, ,, ,, ,,
338	1–5	2–10	Both fast.
343	1–10	2–10	,, ,,
346	1–5	1–10	Both very fast.

* Very slow mothers.

AGGLUTINOGENS IN PREMATURE INFANTS.

Data from a few premature babies indicate that both agglutinogens are as strongly sensitive at 34 weeks as at full term. In prematures from 28 to 33 weeks B is somewhat weaker than in full-term infants (Table VII). In three Group AB prematures A was slightly weaker in two and equally as strong as B in the third. One 32-week A_2B child gave very weak incomplete reaction for A and only a slightly slow reaction for B.

AGGLUTININS AT BIRTH.

A total of 234 babies' sera (not of Group AB) were tested for the presence of agglutinins and only 66 showed one agglutinin while 12 showed two. Altogether only 80 or 34% of the babies had any demonstrable agglutinin at birth. In Table VIII the

presence and absence of agglutinins in babies which are homospecific for group with their mothers are compared with the

TABLE VII.

Premature Infants. Agglutinogen Sensitivity and Development of Agglutinins.

Reg. No.	Age in Weeks.	Reaction Time in Mins.	Mother's Group.	Agglutinin.	REMARKS.
Group A					
1111	37	4–15	O	..	Baby died 7th day.
1800	38	2–10	O	..	
1576	34	2–30	A	β	Agglutinin weak.
1730	34	1–10	A	none	Meningocoele—died.
Av. reaction time ..		2·3–16·3			
Group B					
1231	34	2–10	B	α	α reacted 5–15′.
1467	38	2–20	AB	none	Twin, other stillborn.
1612	30	6–incom.	AB	α	Macorated; α weak.
1614	38	2–15	B	none	Wt. 3 lbs. 11 oz.
1877	39	2–10	B	none	Asphyxiated Wt. 4½ lbs.
1961	28	3–20	A	none	
2030	36	2–30	B	none	Mother—Eclampsia.
2291	32·5	4–30	B	none	Wt. 3 lb. 12 oz.
2329	40	2–20	A	none	Wt. 3 lb. 11 oz.
2394	32	2–30	B	none	
2436	38	3–10	B	none	
Av. reaction time ..		2·6–23			
Group AB		A / B			
1452	35	3–30 / 2–30	AB	..	
1777	27	3–30 / 2–20	AB	..	
1838	36	1–10 / 1–10	AB	..	
Group A_2B		A_2 / B			
1676	32	40–incom. / 2–30	A_2B	..	
Group O					
1359	32	.. / ..	B	β	Baby's own β, 3–30′.
1641	36	.. / ..	A	none	
1620	28	.. / ..	A	$\alpha\beta$	Baby's α, both weak.
1765	37	.. / ..	A	none	
1999	32	.. / ..	O	none	
2230	32	.. / ..	O	β	Strong β, 2–30′.
2408	32	.. / ..	O	none	

condition in heterospecific babies. Among these 190 babies in Table VIII, 65 possessed agglutinin or 34·2%. Among the 111 homospecific babies, only 36% had agglutinins at birth while 30·4% of the 79 heterospecific babies had them. Only 11 of these 190 cord bloods contained both agglutinins. In European races about half of the babies have demonstrable agglutinins at birth (Boyd, 1939). This difference may be related to the general higher titre of the agglutinins in western peoples than among Indians (Greval, unpub. data). Since these figures show almost the same percentage of agglutinins among heterospecific children as among homospecific, this seems to indicate that agglutinins in cord blood are those of the baby and not of the mother derived by diffusion, as suggested by Hirszfeld (1928). There is evidently, however, some mechanism which usually suppresses the production of a baby's agglutinin which would be incompatible with the mothers' red blood cells. That the development of a baby's own agglutinin is probably least hampered in homospecific children of Group O mothers is demonstrated by Table IX. Among 37 such children, 26 possessed agglutinins, which is more than twice as frequent as among the mixed population. Of these, 19 possessed α and 16 had β while both were present in 9.

TABLE VIII.

Babies' Agglutinins at Birth in relation to Mothers' Group.

Homospecific.			Heterospecific.		
Present.	Absent.		Present.	Absent.	
41 (36%)	70		24 (30%)	55	
α	β	$\alpha\beta$	α	β	$\alpha\beta$
19	13	9	15	7	2

TABLE IX.

Agglutinins at Birth in Homospecific Babies of Group O Mothers.

Total.	None.	α	β	$\alpha\beta$
37	11 (29·7%)	10	7	9

Altogether only 12 of all the babies' sera tested had both agglutinins; in 3 of these α was stronger than β, in 4 they were equal in strength and in 5 the stronger was β. The α agglutinin of 3 of these 12 children was incompatible with their mothers' r.b. cells.

Titres of babies' sera have not been measured. Among the 66 cord bloods showing only one agglutinin, 38 possessed α and 28 had β. The greater preponderance of α at birth is related to the higher percentage of Group B than Group A in Bengal. It may also be correlated with the greater sensitivity of agglutinogen B at birth as shown above.

Table X shows the various combinations of mother-child blood groups, agglutinins and agglutinogens in 193 matching pairs. In both the small samples of Group A and Group B babies here a little more than 25% showed agglutinins. This table shows no exceptions to the Bernstein hypothesis of blood group inheritance according to which Group O mothers can never have AB children nor AB mothers Group O children.

TABLE X.

Mother-child combinations of blood groups at birth in 193 pairs of Bengalis.

Baby.	O_0	O_α	O_β	$O_{\alpha\beta}$	A_0	A_β	B_0	B_α	AB	
Mother.										
$O_{\alpha\beta}$ 60	8	9	5	8	11	4	5	10	0	
A_β 54	10	1	1	3	21	6	7	0	5	
B_α 62	10	4	1	0	2	0	31	5	9	
AB 17	0	0	0	0	4	1	5	1	6	
Total 193	28	14	7	11	38	11	48	16	20	Total 193

Agglutinins were found in the sera of 6 among 22 premature babies, not of Group AB (see Table VII). Only 2 in 11 premature children of Group B showed agglutinin. One of these was a 34-week premature which had α agglutinin only slightly slower than normal in reaction. The other was 30 weeks and showed very weak α in which the reaction was still incomplete after an hour. Among 7 Group O premature children, only 3 showed any agglutinin (Table VII) and one of these was a 28-week foetus in which traces of both agglutinins were found. The other two were 32 weeks old and both had well-developed β agglutinin. These few data show that both agglutinins may be already developed as early as the twenty-eighth to the thirtieth week.

A few cases of false agglutination in cord sera as recorded by Thomsen (see Wiener) were observed, and these broke up upon rotation and standing.

Boyd (1939) states that the agglutinins of the new-born are never those that act on the mother's cells. Since the reverse often occurs there seems to be no reason why a baby should not have its own agglutinin which is incompatible with its mother. The foregoing data suggest that the agglutinins in cord blood are proper to the baby even when they are the same as that in the mother's blood. Thus far seven babies with agglutinins incompatible with their mothers' cells have been found among 234 (Table XI). It may be significant that three of them were pre-

TABLE XI.

Babies with Agglutinins incompatible with Mothers' Cells.

Reg. No.	Mother's Group.	Baby's Group.	Baby's own.	Baby's Condition.
1286	AB	A_β	β	Good. Wt. 4 lb. 9 oz.
1359	B_α	O_β	β	Macerated. Premature, 32 weeks.
1475	A_β	$O_{\alpha\beta}$	α	Good. Wt. 5 lb. 9½ oz.
1612	AB	B_α	α	Macerated. Premature, 30 weeks.
1620	A_β	$O_{\alpha\beta}$	α	Weak. Premature, 28 weeks.
1792	A_β	O_α	α	Good. Wt. 8 lb. 2 oz.
2303	A_β	$O_{\alpha\beta}$	α	Good. Wt. 5 lb. 13 oz.

mature at 28, 30 and 32 weeks and that the latter two were found to be macerated at time of delivery. The other four were all reported in good condition at birth; one was a pound below average weight, two were a few ounces only below par and one was over two pounds above average weight for Bengalis. Since mothers' and babies' bloods were usually tested on different days, the baby's first, these unusual cases were only noticed when recording results and it was not possible to repeat the tests on the baby's sera.

EFFECTS OF HETEROSPECIFIC PREGNANCIES.

It is now generally agreed that an heterospecific pregnancy has no deleterious effect on the foetus. Koller (1931) showed that Hirszfeld's earlier contention that heterospecific infants were lighter at birth than homospecific ones was not true.

In a comparison of the weights at birth of 114 full-term homospecific babies with those of 109 full-term heterospecific babies delivered at the Lady Dufferin Victoria Hospital, Calcutta, both the range in weights and average weights in the two groups were found to be almost identical. The average weight of the homospecific group was 5 pounds 15⅛ ounces and of the heterospecific lot 5 pounds $13\frac{3}{10}$ ounces (see Table XII). Thus far

it has not been possible to discover any correlation between miscarriage, eclampsia of pregnancy or digestive disorders in sucklings and the blood group relationship of mother and child.

TABLE XII.

Comparison of Physical Condition of Homospecific and Heterospecific Infants and their Mothers.

	104 Homosp. Pairs.	101 Heterosp. Pairs.
Av. wt. of baby at birth ..	5 lb. 15$\frac{1}{2}$ oz.	5 lb. 13$\frac{3}{10}$ oz.
Number of babies over 6$\frac{1}{2}$ lb. ..	21	21
,, ,, ,, No. 5 lb. or less	9	12
,, ,, ,, premature ..	14	13
Prenatal Eclampsia	2	2
Oedema of feet (prenat.) ..	0	3
Prenatal pyurea	3	5

SUBGROUPS A_2 AND A_2B.

At the beginning of the investigation only slow reacting Group A cells were tested for the subgroups A_1 and A_2. This was done by making α' serum each time as described above. Later some standard α' serum was prepared from known A_2 individuals and all Group A cells were tested as routine.

Table XIII shows the distribution of subgroups A_1 and A_2, A_1B and A_2B among 300 Bengali babies and 321 women in Calcutta. As might be expected from the lower frequency of Group A in India subgroup A_2 is rare here, less than half as frequent as reported for Londoners by Taylor (1939).

TABLE XIII.

Frequencies of Subgroups A_1, A_2, A_1B and A_2B in Bengalis.

Totals	A_1	A_2	A_1B	A_2B
300 babies ..	68	7 (2·3%)	23	1 (0·3%)
321 mothers ..	90	4 (1·2%)	21	5 (1·5%)

The seeming discrepancy between the frequency of A_2 in mothers and in babies in Table XIII disappears when the percentage is taken in the total persons in Groups A and AB. Among 99 babies in groups A and AB, 8 (8·1%) had A_2; among

120 mothers, 9 (7·8%) had A_2. Matta (1937) found even less frequent A_2 among Egyptians. In New York Landsteiner and Levine (1930) found that among Group A and AB persons 37·1% of Negroes possessed A_2 and 13·6% of Whites had A_2.

All persons thus far found to possess agglutinogen A_2 were Brahmins or Muslims, except three. Of the 17 persons with A_2, 8 were Muslims and 6 were Brahmins. These two communities in Calcutta probably have closer racial affinities with the West than the other Bengalis.[1]

TABLE XIV.

Inheritance of subgroups and agglutination times of A_2 cells in 15 mothers and their babies.

Reg. No.	Mother.		Baby.			Remarks.
	Group.	Agglutination time in mins.	Group.	Agglutination time in mins.	Agglutinin.	
1090*	A_2B	10–40	A_2	10–incom.	none	
1373	A_2	3–15	O	..	..	
1467	A_2B	15–incom.	B	..	..	Mother's cells reaction see Table XV.
1612	A_2B	15–incom.	B	..	..	Baby stillborn.
2238	A_2	2–incom.	A_1	2–30	none	
2304*	A_2B	1–20	A_2	3–incom.	none	Mother's B weaker than her A_2.
2429*	A_2	3–incom.	A_2	4–incom.	none	
2416	A_2B	3–incom.	B	..	..	
2182*	A_2	4–incom.	A_2	11–incom.	none	
1051	O	..	A_2	5–incom.	..	Khatri (non-Bengali).
1096	B	..	A_2	5–incom.	..	
1611	O	..	A_2	5–incom.	β	Baby's β of full strength.
1676*	A_2B	10–40	A_2B	40–incom.	..	Sikh (non-Bengali) Baby 32 wk. premat.
2122	O		A_2	5–30	none	
2399	B		A_2B	10–incom.	..	

* A_2 in both mother and baby.

Five of the ten mothers who had A_2 also had babies with A_2 as shown in Table XIV. (For inheritance of A_2 see Matta, *1937*, and Darh, *1938*.) The sensitivity of A_2 cells in the newborn is variable, but in all cases was found to be below that in adults. The average times taken for agglutination to begin in

[1] Mohammedans of Calcutta were found to resemble up-country Khatris in their blood group proportions, and not the local agrarian Mohammedans (Macfarlane, E. W. E., *Man*, in press).

mothers was 6·6 minutes and in babies 9·1 minutes. In one Group A_2B woman the B agglutinogen was slower than the A_2, a very rare condition. Only one A_2 baby in eight had any demonstrable agglutinin β, and in that child it gave as strong a reaction as an average adult.

Precautions needed in testing for Subgroups of A.

Although the reaction time of A_2 cells is usually longer than that of A_1 cells, this does not hold in all cases and cannot safely be relied upon to distinguish between the subgroups in field work without the confirmatory absorption test. Some people have very weak A_1 agglutinogen which reacts as slowly as A_2 and likewise never gives a complete reaction. Two such examples are shown in Table XV for Group A_1 and Group A_1B and are compared with reaction times for A_2 and A_2B.

Table XV.

Reaction times of some weak A_1 and of A_2 cells in minutes.

Reg. No.	Subgroup.	With equal vol. of serum.	With twice vol. of serum.	With half vol. of serum.
By. 977	A_1	5–incom.*	..	No reaction.
By. 1051	A_2	5–incom.	..	,,
,, 1096	A_2	5–incom.	..	,,
Mo. 1251	A_1B	3–incom.	..	10–incom.
,, 1467	A_2B	15–incom.	1–15	..
,, 1373	A_2	3–15	..	..
†By. 1676	A_2B	40–incom.	7–30	No reaction.

* Incomplete after 60 mins. † Premature 32 weeks.

Another important detail of procedure when dealing with low-sensitivity A cells is the relative concentrations of cell suspension and test serum in each reaction. The standard procedure of the Imperial Serologist's laboratory of adding one measured drop of 2% cell suspension to a similar measured drop of test serum gives a reaction with these weak agglutinogens. Some of them give no reaction when there are two drops of the cell suspension and only one drop of test serum (Table XV). Sometimes, if two drops of test serum are used to one drop of cell suspension the reaction is considerably speeded up.

An A_2 reaction was detected in an A_2B premature baby of 32 weeks.

Blood Types.

A hundred matching pairs of mothers and babies were typed and no anomalous or unexpected combinations were found, i.e. the children of Type M and Type N mothers always possessed their mothers' agglutinogen; also Type M mothers never had

Type N babies nor Type N mothers Type M offspring (Table XVI). There were 54 pairs homospecific for type and 46 heterospecific pairs.

TABLE XVI.

Mother-child combinations of blood types at birth in 100 pairs of Bengalis.

Baby.	M	MN	N	Mother's %
Mother. M ..	18	16	0	M 34
MN .	14	34	6	MN 54
N ..	0	8	4	N 12
Baby's % ..	M 32	MN 58	N 10	..

The blood type percentages in a random sample of 130 consisting of the 100 mothers shown in Table XVI plus 30 unpaired mothers and babies were: M 35·4, MN 50·7, N 13·9. In a sample of 300 Indians in Calcutta Greval found: M 42·7%, MN 46·7%, N 10·7%. The only other communities in the world thus far typed which have proportions of the same order as Bengalis are the Bedouin of Iraq (Kayssi, Boyd and Boyd, 1938).

Blood type agglutinogens were present in all cord bloods examined, as well as in those of 14 premature infants from 32–38 weeks old. In no blood tested was a type undetectable. According to Boyd (1939) agglutinogens A, B, M and N are detectable in the foetus after the first few months.

ACKNOWLEDGMENTS.

This investigation was suggested by Col. S. D. S. Greval, I.M.S., and I am indebted to him for valuable help and advice. I am grateful to the Lady Superintendent and Staff of the Lady Dufferin Victoria Hospital, Calcutta, for co-operation in providing the bloods. Part of a grant from the Royal Society, London, was used to defray incidental expenses involved.

SUMMARY.

1. A total of 252 pairs of bloods from Bengali mothers and babies were grouped and 100 of these were also typed. 50% of the infants had the same blood group as their mothers.

2. Agglutinogen A in cord blood of full-term babies was found to be definitely less sensitive to test sera than in adults, although agglutinogen B was only slightly below normal in this respect.

3. Sensitivity of A_1 is highly variable in adults and evidence is presented from homospecific Group A mothers and babies to show that fast and slow reacting A_1 are inherited.

4. A demonstrable agglutinin was found in 34% of 234 cord bloods. Only 12 of them showed both agglutinins.

5. There is evidence that the agglutinins in cord blood are those of the baby and not of the mother.

6. Seven babies among 234 were found to have an agglutinin incompatible with the mothers' r.b. cells.

7. Heterospecific pregnancies yielded, on the average, no smaller infants nor more prematures than homospecific.

8. Among 26 premature babies agglutinogens A, B, M and N were found to be well developed by the twenty-eighth week of pregnancy. Only 6 out of 22 not in Group AB showed any agglutinin.

9. Among 219 mothers and babies in Groups A and AB, 202 (92·2%) possessed A_1 and 17 (7·8%) had A_2. Certain precautions to be observed in testing for subgroups of A are given.

10. One hundred pairs of mothers and babies were typed and no unexpected combinations were found. Of these, 54 pairs were homospecific for type and 46 heterospecific. A sample of 130 unrelated Bengalis showed M 35·4%, MN 50·7% and N 13·9%.

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The Alimentary Canal of *Labeo rohita* (Hamilton).

By DAYA SHANKAR SARBAHI.

(*Communicated by Dr. B. Prashad.*)

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Introduction.

The account of the alimentary canal of the Indian Carp *Labeo rohita* (Ham.), embodied in the following pages, formed part of a thesis submitted by the author for the degree of Doctor of Science of the University of Lucknow. For publication, the thesis has been divided into a series of papers, each dealing with a particular system. The first article of the series dealing with the endoskeleton of the Rohu was published in this Journal (Sarbahi, 1933), the second is appearing now, and I hope the remaining ones will follow in quick succession.

The work was carried out in the Department of Zoology, University of Lucknow, under the kind guidance of Professor K. N. Bahl. I am indebted to Prof. Bahl for taking keen interest in the progress of the work and for valuable advice and criticism. My sincere thanks are due to Prof. E. S. Goodrich of Oxford and Prof. F. J. Cole of Reading for valuable suggestions and criticism. Acknowledgments are also due to Dr. Baini Prashad and Dr. S. L. Hora for the final revision of the manuscript and foi seeing it through the press. I also wish to express my grateful thanks to Dr. M. L. Bhatia, Lecturer in Zoology, University of Lucknow, for seeing the illustrations take their final form.

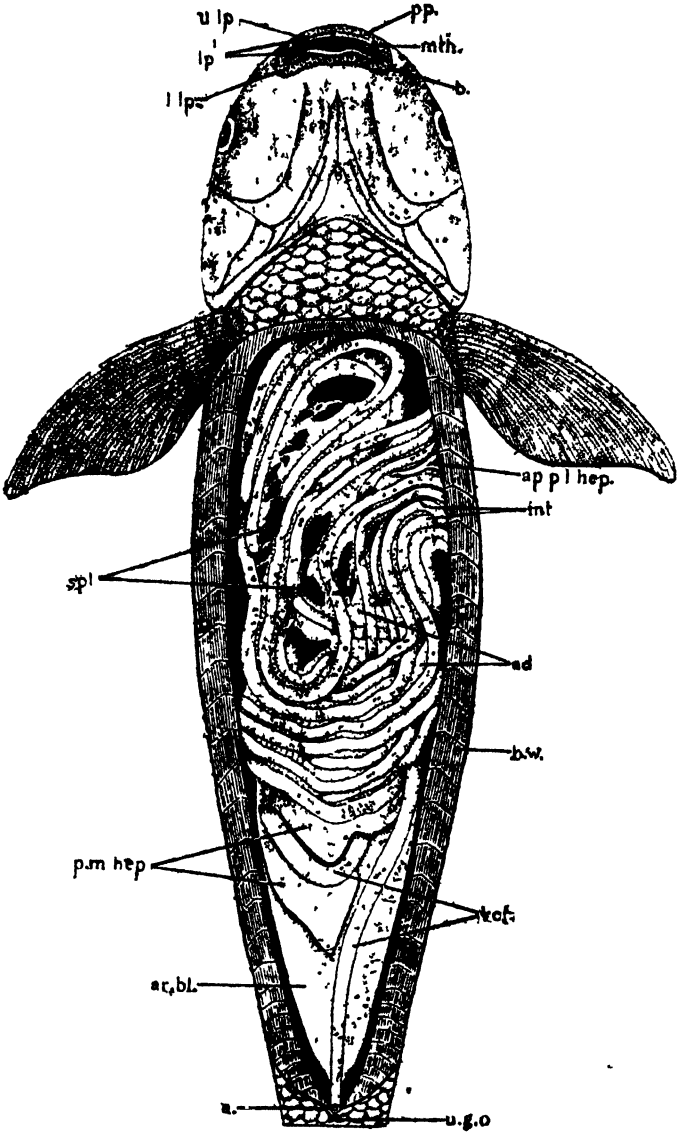
The Alimentary Canal.

The organs concerned with the capture, digestion and absorption of food comprise the alimentary canal and its associated glands, the liver and the pancreas. The alimentary canal (Text-figs. 1 and 2) is an extremely elongated tube, which begins at the mouth and extends backwards throughout the length of the coelomic cavity, coiling repeatedly and filling up the greater part of the abdomen, and communicating behind with the exterior through the anal opening. The following regions can be recognized in the digestive tube: the *mouth*, the *buccal cavity*, the *pharynx*, the *oesophagus*, the *intestinal bulb*, the *intestine* and the *rectum*. The exact boundaries of these regions are not well marked, but are indicated either by variations in calibre, or by changes in the character of their epithelial lining, or by special valves at the junctions of the adjoining regions.

1. *The Mouth.*[1]

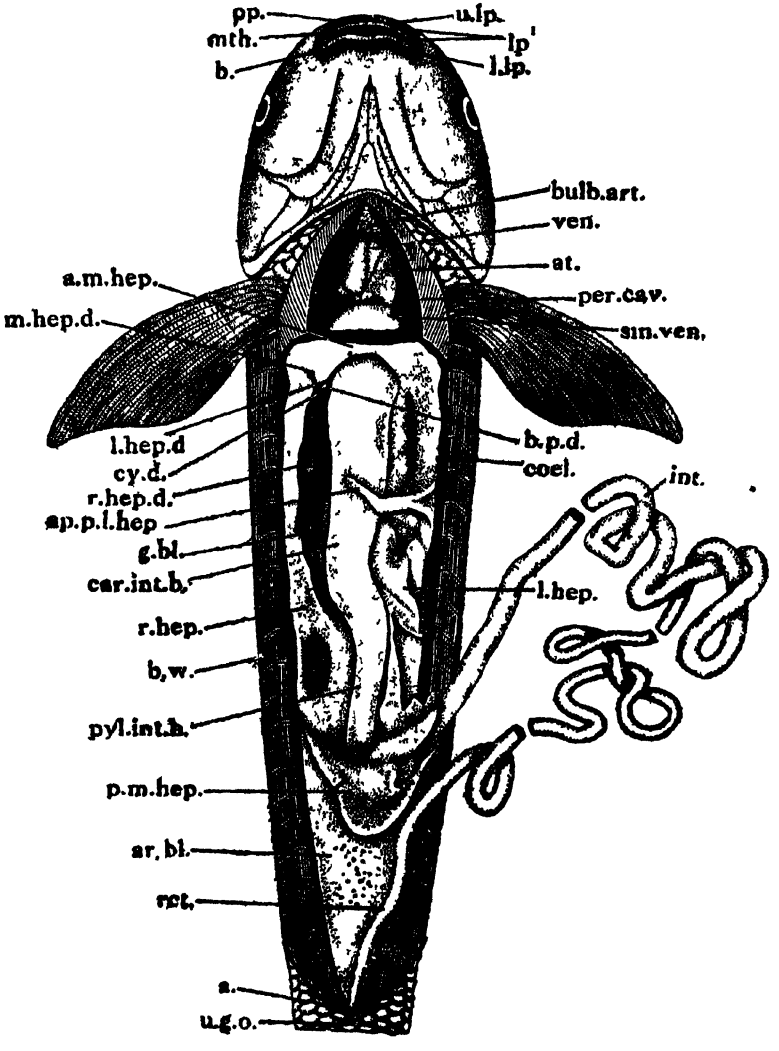
The soft lips bounding the mouth are vertical folds, the broad free margins of which are densely covered with four to five

[1] The mouth of *Cirrhina mrigala* (Ham.), a fish often mistaken by fishermen for Rohu, is broader and bounded by thinner lips. Further, the lips of *Cirrhina* are not provided with inner folds nor are they covered with conical papillae which form such a prominent feature of the lips of Rohu.



TEXT-FIG. 1.—Ventral view of the internal viscera *in situ*. ×⅔.

a., anus; *ad.*, fatty tissue; *ap.p.l.hep.*, appendicular process of the left hepatic lobe; *ar.bl.*, air-bladder; *b.*, barbel; *b.w.*, body wall; *int.*, coils of the intestine; *l.lp.*, lower lip; *lp*[1]., folds on lips; *mth.*, mouth; *p.m.hep*, postero-median hepatic mass; *pp.*, papillae on lips; *rct.*, rectum; *spl.*, splenic tissue; *u.g.o.*, urinogenital aperture; *u.lp.*, upper lip.



TEXT-FIG. 2.—Ventral view of the internal viscera after the removal of the fat and splenic tissue, showing the uncoiled intestine. × ½.

a., anus, *a.m.hep.*, anterior median hepatic lobe; *ap.p.l.hep.*, appendicular process of the left hepatic lobe; *ar.bl.*, air-bladder, *at.*, atrium; *b.*, barbel; *b.p.d.*, common bile and pancreatic duct; *bulb.art.*, bulbous arteriosus; *b.w.*, body wall; *car int b.*, cardiac region of the intestinal bulb; *coel.*, coelomic cavity; *cy.d.*, cystic duct; *g.bl.*, gall-bladder, *int.*, intestine, *l.hep.*, left hepatic lobe; *l hep.d.*, left hepatic duct, *l.lp.*, lower lip; *lp*¹., folds on lips; *m.hep.d.*, median hepatic duct; *mth.*, mouth; *per.cav.*, pericardial cavity; *p.m.hep.*, posterior median hepatic mass; *pp.*, papillae on lips; *pyl.int.b.*, pyloric region of the intestinal bulb; *rct.*, rectum; *r.hep.*, right hepatic lobe; *r.hep.d.*, right hepatic duct; *sin.ven.*, sinus venosus, *u.g.o.*, urinogenital aperture; *u.lp*, upper lip; *ven.*, ventricle.

rows of darkly pigmented conical papillae. The inner fold of each lip is narrow and muscular and is devoid of papillae.

2. *The Buccal Cavity.*

The mouth leads into the *buccal cavity* (Text-fig. 3), which is depressed dorso-ventrally and measures roughly about 1·5 in. in length and 1·2 in. in width in a specimen about two feet in length.[1] The roof is slightly arched and is supported by the base of the cranium, while the floor is more or less flat and is supported by the small basi-hyal. The buccal cavity is lined with a thick mucous membrane produced into minute papilla-like outgrowths, there being no ridges and grooves. The mucous membrane of the floor is supported by thick muscles but a distinct tongue is absent.

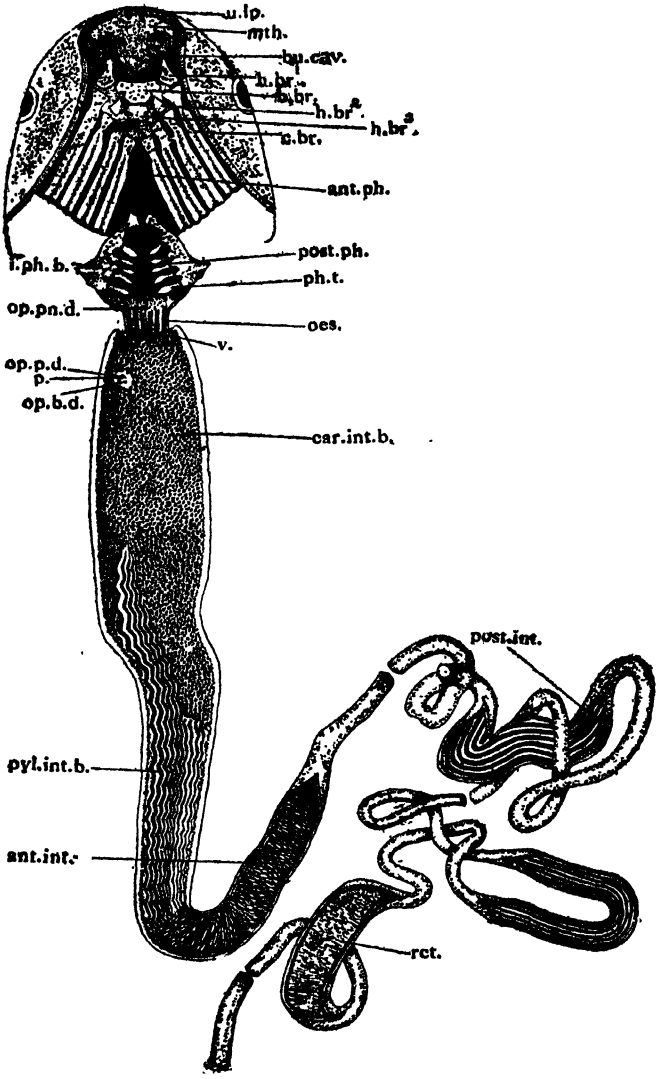
3. *The Pharynx.*

The buccal cavity broadens posteriorly and passes into the *pharynx* (Text-fig. 3), which is also dorso-ventrally flattened. It is bounded by the gill-arches on either side and extends backwards a little beyond the pharyngeal teeth, measuring about 3·5 in. in length. Two divisions of the pharynx can be distinguished at once: (1) an *anterior*, and (2) a *posterior*. The anterior pharynx extends from the first to the last gill-slit and is about 2·3 in. in length; the posterior pharynx includes the region of the pharyngeal teeth and extends up to the anterior end of the oesophagus, being about 1·2 in. in length.

The *anterior pharynx* is narrow in front but wide behind; at its anterior end it is about 1·2 in. wide, but rapidly increases in width, reaching its maximum a little in front of the beginning of the posterior pharynx, where it is about 2·5 in. wide. The roof is supported by the base of the cranium while the floor is supported by the hypo-branchials and the median basi-branchial. It is perforated latero-ventrally by the gill-slits through which

[1] The various parts of the alimentary canal were measured in several adult specimens. Although the relative lengths of the various parts are undoubtedly subject to individual variations, in general it was found that the length of the intestine alone was from twelve to fourteen times the length of the fish. The measurements of various parts given below refer to this specimen and give an idea of their comparative lengths.

Length of the fish	2 ft.
Length of the whole tract, uncoiled, from the mouth to the anus	32 ft.
1. Buccal Cavity	1·5 inches.
2. Pharynx	3·5 inches.
3. Oesophagus	1·0 inch.
4. Intestinal Bulb	8·5 inches.
5. Intestine	28 feet and 1·5 inches.
6. Rectum	2 feet and 8 inches.



TEXT-FIG. 3.—Dissection of the alimentary canal. ×$\frac{3}{4}$.

ant.int., anterior region of the intestine; *ant.ph.*, anterior pharynx; *b.br.*, basibranchial; *bu.cav.*, buccal cavity; *car.int.b.*, cardiac region of the intestinal bulb; *c.br.*, ceratobranchial; *h.br*^{1}., first hypobranchial; *h.br*^{2}., second hypobranchial; *h.br*^{3}., third hypobranchial; *i.ph.b.*, inferior pharyngeal bone; *mth.*, mouth; *oes.*, oesophagus; *op.b.d.*, opening of the bile-duct; *op.p.d.*, opening of the pancreatic duct; *op.pn.d.*, opening of the pneumatic duct; *p.*, papilla., *ph.t.*, pharyngeal teeth; *post.int.*, posterior region of the intestine; *post.ph.*, posterior pharynx; *pyl.int.b.*, pyloric region of the intestinal bulb; *rct.*, rectum; *u.lp.*, upper lip; *v.*, valve-like structure separating the oesophagus from the intestinal bulb.

the pharynx communicates with the branchial chamber. The wall of the anterior pharynx is lined with a thick mucous membrane bearing minute papillae both on its roof and floor. Minute gill-rakers supported by the branchial arches project into the pharyngeal cavity and serve to filter the water which passes out into the branchial chamber and bathes the gills. Since the branchial arches are latero-ventral in position, the area of uninterrupted surface is greater on the roof than on the floor.

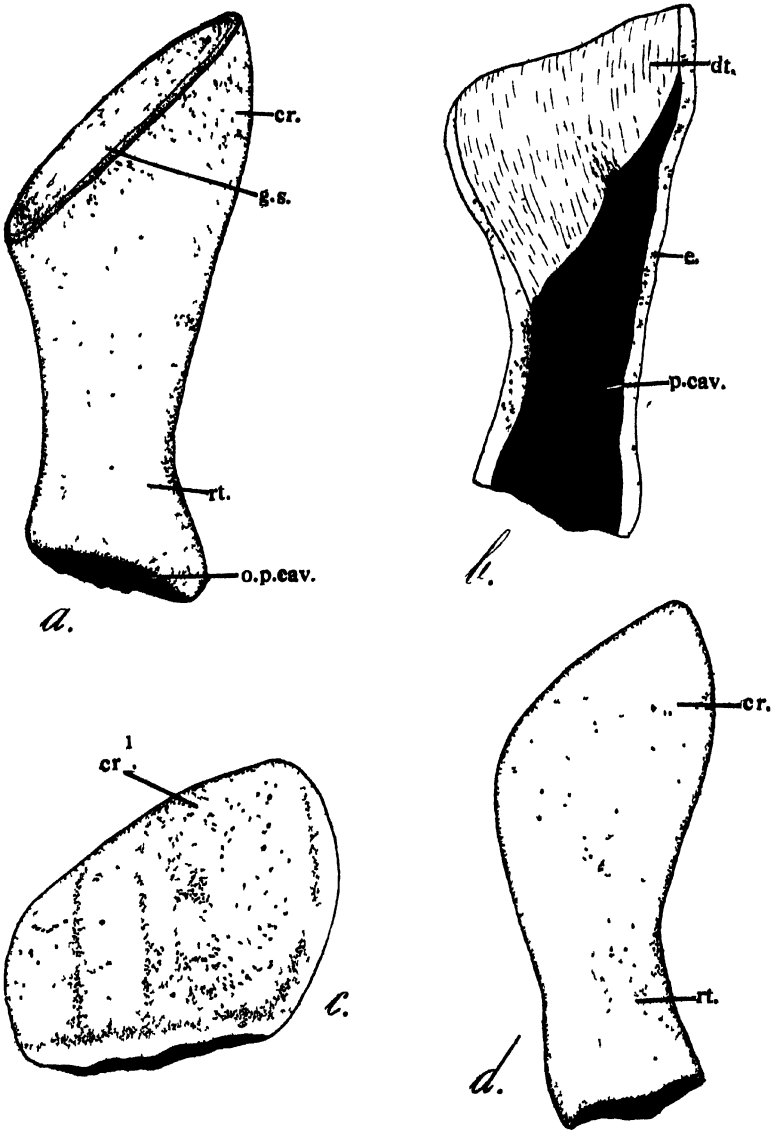
The anterior pharynx ascends up a little at its posterior end and passes into the *posterior pharynx* which is about 1·2 in. wide at its broadest place and only 0·8 in. at its narrowest. The roof bears the horny pad of the basi-occipital, the latero-ventral walls are beset with pharyngeal teeth, while the median region of the floor is lined with a transversely folded mucous membrane.

The Pharyngeal Teeth[1].—The floor of the posterior pharynx behind the gills is supported by the two inferior pharyngeal bones (Text-fig. 3). These bones are armed with strong crushing teeth which are closely set and are arranged in three rows, the teeth of one row alternating with those of the adjoining one. The truncate grinding surfaces are so closely adpressed against each other as to almost exclude the intervening spaces, and together form a common semicircular chewing area on either side, which, working against the corresponding left or right area on the horny pad of the roof, no doubt serves to crush the food.

The teeth which are all alike (homodont) are compressed and have their apical regions broadened. Each tooth consists of two parts (Text-fig. 4*a*) : (1) a basal part or *root* lying imbedded in the mucous membrane and ankylosed at its base with the pharyngeal bone, and (2) an upper part or *crown* that projects into the pharyngeal cavity. The root is narrow and cylindrical above but broadens out at its base, while the crown is laterally compressed and elliptical in section. The root is hollow and contains a large pulp-cavity (Text-fig. 4*b*) which continues into the crown as well. The pulp-cavity contains connective-tissue pulp with blood-vessels and nerves that enter into it through the highly fenestrated outer lateral surface of each inferior pharyngeal bone.

Besides the functional teeth which are attached to the inferior pharyngeal bones, there may be observed other teeth in various stages of development, freely imbedded in the mucous membrane behind or between the functional ones and destined to replace the old teeth when they get worn off and are shed. In the new teeth (Text-figs. 4*c* and *d*) the enamel completely

[1] The teeth of *Labeo rohita* closely resemble in shape and structure those of *Cirrhinus melanostigma* and *Labeo calbasu* as described by Yuanting, T. Chu (1935).



TEXT-FIG. 4.—Pharyngeal teeth of *Labeo rohita* (Ham.). ×6.

a. Side view; *b*. Sagittal section; *c*. Growing tooth; *d*. Fully developed tooth.

cr., crown; *cr*^{1}., crown of a growing tooth; *dt*., dentine; *e*., enamel; *g.s*., free grinding surface; *o.p.cav*., opening of the pulp cavity; *p.cav*., pulp cavity; *rt*., root.

covers the dentine of the crown but as these teeth begin to function, the enamel at the top gets worn off and the underlying dentine becomes visible on the cutting surface of the crown.

Since old teeth are replaced by new ones several times during the life of the fish, the dentition is described as *polyphyodont*.

The mouth, the buccal cavity and the pharynx subserve digestive as well as respiratory functions. The act of swallowing brings about the passage of food to the oesophagus and at other times of water to the gills. Most fishes, like Amphibians, Reptiles and Birds, swallow their food without chewing. But in *Labeo*, as in other carps, the pharyngeal teeth working against the dorsal horny pad effectively crush hard and solid food-masses which may be of a large size, so that they can easily pass into the narrow oesophagus.

4. *The Oesophagus.*

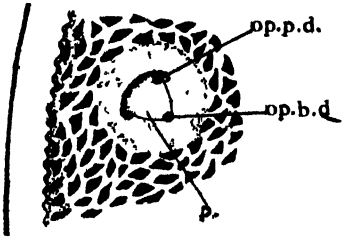
The pharynx at its posterior end descends a little and passes into the narrow tubular *oesophagus* (Text-fig. 3), which is a short thick tube, about an inch long and a quarter of an inch in diameter. The mucous membrane lining the wall is raised into seven prominent longitudinal folds and several smaller folds. The *pneumatic duct* leading into the air-bladder arises here as a dorsal diverticulum of the oesophagus. On entering the body-cavity, the oesophagus expands into the intestinal bulb. Externally there is no well-marked indication of the passage of the oesophagus into the intestinal bulb except for an appreciable increase in the diameter of the latter. Internally the two are separated by a valve-like structure formed by an increase in size of the folds of the mucous membrane of the oesophagus. The valve-like structure is situated slightly behind the level of the posterior wall of the pericardium.

5. *The Intestinal Bulb.*

A true *stomach*, comparable to that of other bony fishes, is absent in *Labeo rohita*, but its place is taken up by an enlargement of the intestine, which, for convenience, is designated the *intestinal bulb*[1] (Text-figs. 2 and 3). It lies dorsal to the coils of

[1] The question of the disappearance of the stomach is difficult to settle. In fishes with a well-defined stomach, the bile and pancreatic ducts open in the anterior region of the intestine. But in *Labeo rohita* the openings of these ducts lie just behind the oesophagus. Whether the intestinal bulb is a converted stomach or the stomach is reduced altogether is still a moot point. It would be interesting to know the position of the openings of the bile and pancreatic ducts and their relations to the stomach (if present) and intestinal bulb in the young stages of Rohu.

the intestine proper and ventral to the air-bladder, the extensive mass of the liver lying on either side of it. The bulb is a more or less thick straight tube with a slight curvature about the middle of its length, and extends almost to the posterior end of the abdominal cavity, being about 8·5 in. in its entire length. It attains its greatest width in its first half, behind which it narrows gradually. Two regions can be distinguished in the bulb according to the foldings of its mucous membrane: the proximal region, comprising more than half of its length, is called the *cardiac region*, while the distal portion comprising less than half of its length is called the *pyloric region*. The mucous lining of the cardiac region presents a honey-combed appearance, brought about by the union and anastomosis of its folds, while the mucous membrane of the pyloric region is disposed into a number of thick longitudinal folds running in a zig-zag course, which can be readily seen through the semi-transparent wall of the intestinal bulb. The height and the complexity of the folds decreases as the region of the intestine is reached. For a distance of about two inches in the middle of the bulb, the mucous membrane is partly like that of the cardiac region and partly like that of the pyloric region. The bile and pancreatic ducts open by two separate openings lying close together on a papilla, on the roof of the cardiac region, about a centimetre and a half beyond the valve separating the oesophagus from the intestinal bulb (Text-fig. 5). Posteriorly the intestinal bulb curves to the left and insensibly passes into the intestine. The *pyloric caeca* commonly found in most teleostean fishes are altogether absent in this form.



TEXT-FIG. 5.—Papilla magnified to show the openings of bile and pancreatic ducts. ×2.

op.b.d., opening of the bile-duct; *op.p.d.*, opening of the pancreatic duct; *p.*, papilla.

6. *The Intestine.*

The remaining part of the elongated alimentary tract behind the intestinal bulb is a comparatively thin-walled tube, more or less uniform in diameter but disposed into a large number of complicated convolutions and coils. It is called the *intestine*

(Text-figs. 2 and 3) and fills up the entire ventral portion of the abdominal cavity. Like the intestinal bulb, it shows two regions distinguished by the disposition of its internal mucous folds: (1) a short *anterior* region, in which the mucous folds are arranged in the form of low, obliquely transverse ridges, and (2) a much larger *posterior* region, the mucous lining of which is disposed in distinct longitudinal folds, the posterior region being slightly narrower than the anterior. Both the anterior and the posterior regions of the intestine together attain a length of over *twenty-eight feet.*

The numerous coils of the intestine are bound together and kept in position by the mesentery, in which is imbedded a large quantity of fat.

7. *The Rectum.*

Posteriorly the intestine widens slightly to form the thin-walled *rectum* (Text-figs. 2 and 3), which opens to the exterior through the anus, situated in front of the urino-genital aperture. It is a relatively short chamber, being only about two feet and eight inches in length, and is easily distinguished from the intestine by the presence of inconspicuous, obliquely transverse folds comparable to the folds found in the anterior part of the intestine, the only difference being that in the latter case the folds are quite prominent and can be easily made out with the naked eye, while in the rectum they are inconspicuous and can be made out only with the help of a hand-lens.

The Histology of the Alimentary Canal.

The wall of the alimentary canal, with the exception of that of the lips, the buccal cavity and the pharynx, consists of the following layers: (1) a thin layer of areolar tissue called the *serosa* which is covered over by the coelomic peritoneal cells; (2) the *muscularis*, comprising a layer of circular muscle fibres and a layer of longitudinal muscle fibres; (3) the *sub-mucosa*, a layer of more or less loose connective tissue in which are imbedded numerous small blood-vessels and fine nerve-fibres; (4) the *mucosa*, a layer of variable thickness and complexity according to the region to which it belongs. The deepest layer of this coat farthest from the central lumen consists of a homogeneous, non-cellular, fibrous substance known as the *basement membrane.*

The muscularis and the mucosa show the greatest histological variation regionally but the serosa and the sub-mucosa are fairly constant in their histological details throughout the alimentary canal. There is no trace of a muscularis mucosa, or a stratum granulosum, or a stratum compactum in any part of the canal.

1. *The Lips.*

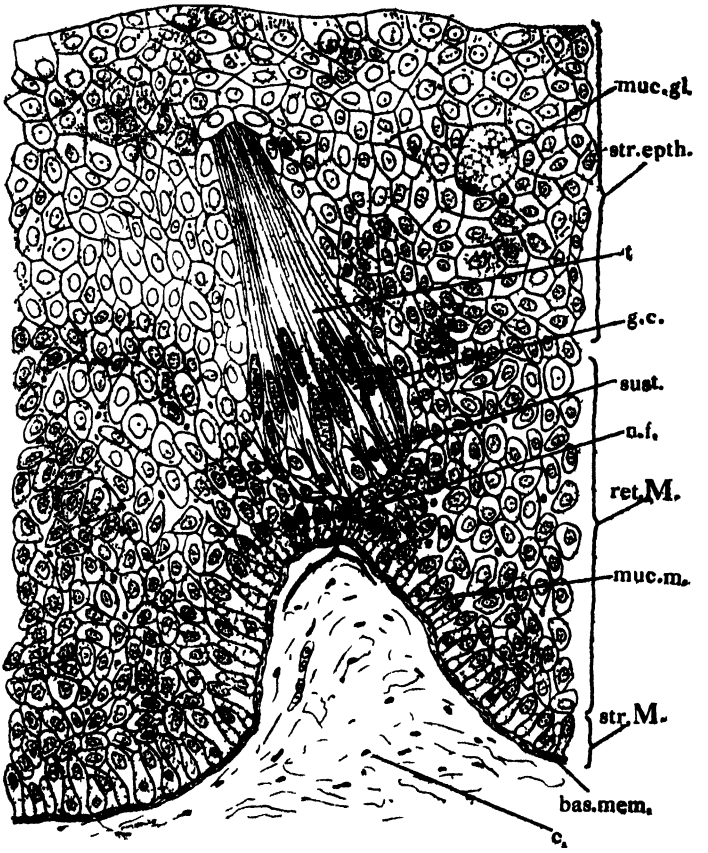
The *lips* are composed of: (1) the *epidermis*, and (2) the *dermis* (Text-fig. 6). The epidermis consists of a number of layers of cells, divisible into two regions: (*a*) an outer region of compactly arranged cells forming the *stratified epithelium*; (*b*) an inner region of loosely arranged cells forming the *rete mucosum of Malpighii*. The deepest cells of the rete mucosum are columnar in shape and resemble (*c*) the *stratum Malpighii* which rests on (*d*) the *basement membrane*. The *columnar cells* are unequal in size and their more or less oval nuclei lie at different levels. The columnar cells regenerate the stratified epithelium. In between the columnar cells lie *oval cells*, each with a clear homogeneous protoplasm and a distinct nucleus, which is smaller in size as compared with the nucleus of an adjoining columnar cell. These oval cells seem to regenerate mucous cells and may therefore be called *mucous-mother cells*. The cells of the stratified epithelium have a regular polygonal shape, whereas the cells forming the rete mucosum of Malpighii are oval in outline, each with a large nucleus and one or more nucleoli. The basement membrane or membrana propria forming the deepest layer of the epidermis is made up of a homogeneous, non-cellular, fibrous substance, more or less wavy in appearance.

No blood-vessels pass into the epidermis.

Underlying the basement membrane is the vascular layer of the *dermis* which at several places projects into the epidermis in the form of papillae. It is composed of connective tissue interspersed with blood-capillaries and bounds a dense layer of connective tissue forming the central core of the lip. Here the fibres are irregularly arranged, run in various directions and enclose bigger vessels. Fine nerve-fibrils enter the papillae.

A number of *taste-buds* or *gustatory organs* are found in the epidermis. These are oval or flask-shaped clusters of epithelial cells and rest upon the papillae of the dermis. Generally, one taste-bud is borne on each papilla, but sometimes two or three may be present on the same papilla; in the latter case, the papilla branches into as many digitiform processes as there are taste-buds borne on it. The cells forming a taste-bud are of two kinds: (*a*) the *gustatory cells*, and (*b*) the *sustenticular* or *supporting cells*. The *gustatory cells* are elongated and taper towards both ends; the part of the cell-body containing the elongated oval nucleus is swollen, while the outer part of each cell ends in a thread-like strip of protoplasm projecting into a pit-like depression in the outer layers of the stratified epithelium. The inner end of each cell almost reaches the basement membrane and is thicker than the outer end. The nerve-fibres of the taste-buds ramify and terminate in these cells. The *supporting cells* vary in shape according to the position they occupy; at the base of the

bud they are narrow and elongated and lie in between the gustatory cells, which they serve to support; at the sides they form a



TEXT-FIG. 6.—A part of the lip in traverse section. ×470.

bas.mem., basement membrane; *c.*, dermis or corium; *g.c.*, gustatory cell; *muc.gl.*, mucous gland; *muc.m.*, mucous mother cell; *n.f.*, nerve fibre, *ret.M.*, rete mucosum of Malpighii; *str.epth.*, stratified epithelium; *str.M.*, stratum Malpighii; *sust.*, sustenticular or supporting cell; *t.*, taste-bud.

sort of envelope, and mostly resemble the surrounding epithelial cells. The supporting cells contain oval or rounded nuclei which stain less intensely than those of gustatory cells. The nuclei of both the gustatory and the supporting cells show a highly granular nucleoplasm with one or more nucleoli. The gustatory cells stain so intensely that quite often the bulbous part of the taste-bud appears as a dark mass of nuclei. The supporting

cells correspond to the nutritive cells and the gustatory cells to the sensory cells of Pictet (1909) and other authors.

A large number of unicellular *mucous glands* or *goblet cells* are also present in the epidermis. They are rounded in shape and contain little or no protoplasm but are full of mucin. The nuclei are flattened and lie at the base on one side of the mucin.

2. *The Buccal Cavity.*

The layers forming the epidermis of the lips are continued into the *mucosa* of the *buccal cavity* (Text-fig. 7), but the *rete mucosum of Malpighii* forms a thick layer occupying about four-fifths of the entire coat. The number of *mucous glands* or *goblet cells* is comparatively small in the anterior part of the buccal cavity, but their number increases in the posterior part. The *sub-mucosa* is reduced because of the excessive development of the adipose tissue and the muscles. The *muscularis* underlying the sub-mucosa consists of both striated and unstriated fibres arranged in an inner longitudinal and an outer circular layer. These muscle-layers are not continuous but are interspersed with adipose and connective tissues.

The *adipose tissue*, besides being associated with the muscularis, forms a thick layer next to it and consists of vesicular cells, rounded or oval in shape, except where closely packed together, in which case they are irregular in shape because of mutual compression. In the muscularis the adipose cells are collected into lobules or definite masses; the cells are full of fat and contain very little protoplasm which encloses a more or less elongated nucleus. The tissue is richly supplied with blood-capillaries.

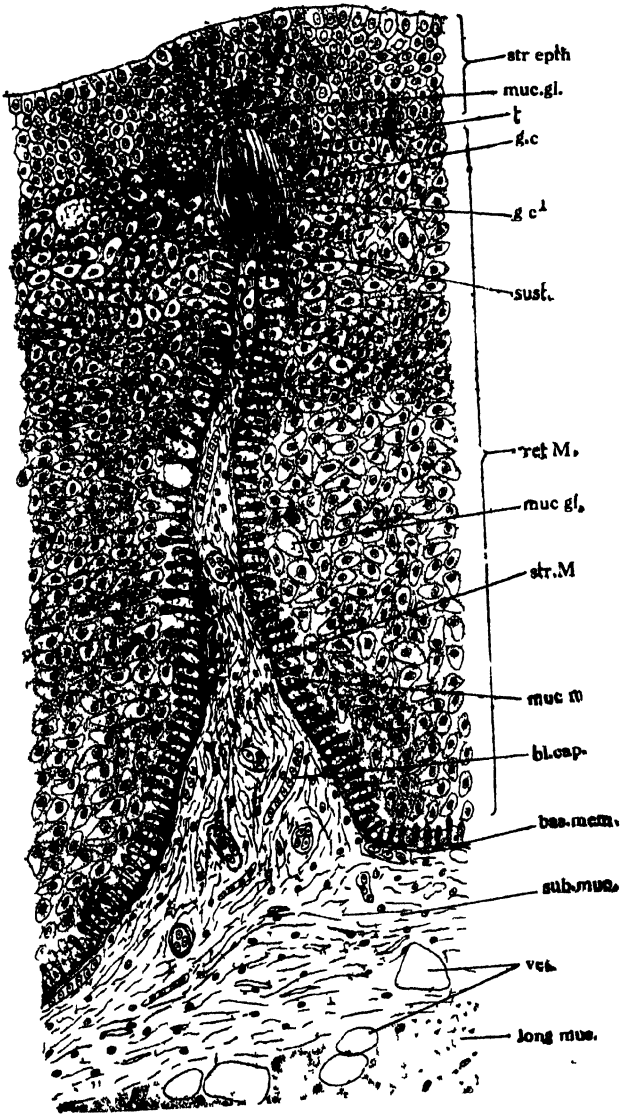
Definitive *salivary glands* are absent in the buccal cavity of Rohu.

3. *The Pharynx.*

The arrangement of the various layers forming the wall of the *pharynx* is similar to that found in the buccal cavity but there are slight differences in histological details.

The *mucosa* (Text-fig. 8) of the pharynx is characterized by the epithelial folds which are not well-marked in the buccal cavity. The *rete mucosum of Malpighii* forms a layer thinner than that in the buccal cavity. Taste-buds[1] are found in very large numbers, indicating thereby the gustatory function of this region. Goblet-cells vary in number and shape in different parts of the pharynx; they are quite numerous practically all over the inner lining of the pharynx; in the floor of the posterior pharynx,

[1] The taste-buds form the palatal organ in the roof of the pharynx, originally described by Weber in 1827. This remarkable organ is crowded over its entire extent with taste-buds.



TEXT-FIG. 7.—Buccal mucosa and underlying layers. ×350.

bas.mem., basement membrane; *bl.cap.*, blood capillary; *g.c.*, gustatory cell; *g.c*¹., elongated nucleus of gustatory cell; *long.mus.*, layer of longitudinal muscle fibres; *muc.gl.*, mucous gland; *muc.m.*, mucous mother cell; *ret.M.*, rete mucosum of Malpighii; *str.epth.*, stratified epithelium; *str.M.*, stratum Malpighii; *sub.muc.*, sub-mucosa; *sust.*, sustentacular cell; *t.*, taste-bud; *ves.*, vesicular cells of adipose tissue.

however, their number is greatly reduced; in the roof of both the anterior and posterior pharynx they present a variety of shape, being sacciform, oval, pear-shaped or spherical; in the floor, however, they are smaller in size and almost rounded in shape.

The *sub-mucosa* like that of the buccal cavity is reduced.

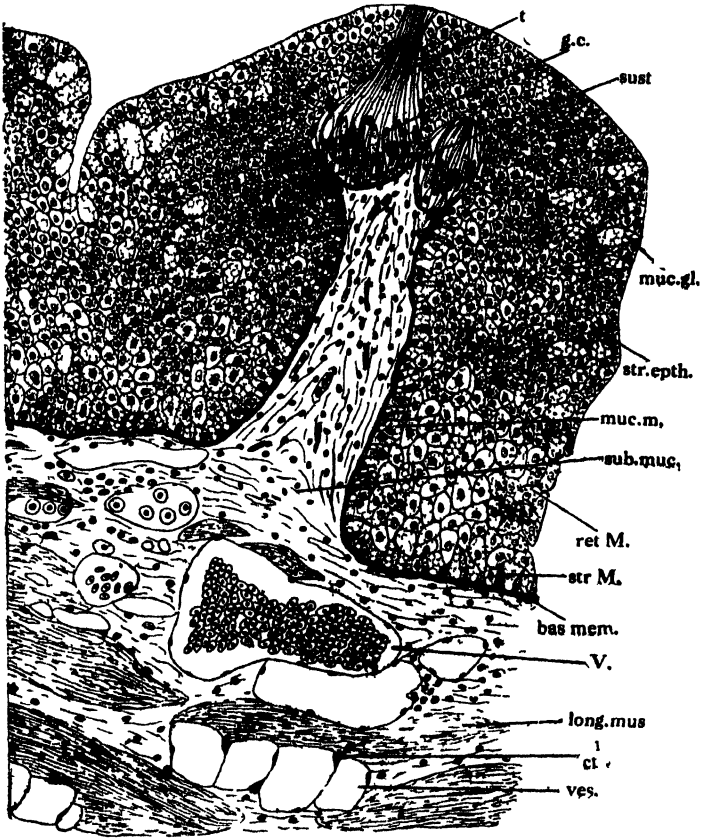
The *muscularis* consists of striated fibres only. In the roof of the pharynx the fibres are arranged in both longitudinal and circular layers, the arrangement being the same as that found in the buccal cavity. In the floor, however, the fibres are arranged mostly in longitudinal bundles forming a more or less continuous layer in the anterior pharynx only. Fine strands of richly nucleated connective tissue lie in between the muscle-bundles.

The *pharyngeal teeth* develop from the latero-ventral part of the posterior pharynx and later become ankylosed to the bony processes of the inferior pharyngeal bones. During their development the mucosa thickens and grows into the sub-mucosa to form the *dental ridge* or *lamina*. The thickened mucosa covering the dental lamina consists of an outer layer of narrow cylindrical cells forming the epithelial layer, and an inner layer of columnar cells forming the stratum Malpighii supported on a thin basement membrane. In the lamina develop the teeth which in early stages consist of the *enamel organ* and the *dental papilla*. The enamel organ which finally gives rise to the enamel of the teeth forms an inverted cup continuous at one end with the dental lamina. The concavity of the cup is filled with a dense mesenchymatous tissue forming the dental papilla, the *anlage* of the dentine and the pulp. The enamel organ consists of an outer fibrous layer and an inner layer of slender columnar cells. The inner enamel cells bound the cup-shaped concavity of the enamel organ. Between the two layers lie a few scattered cells with intercellular matrix forming the enamel-pulp. The dental papilla consists of an outer layer of columnar epithelium surrounding the mesenchymatous cells. The epithelial cells give rise to dentine and the mesenchymatous cells differentiate into the dental pulp.

4. *The Oesophagus.*

The *mucosa* (Text-fig. 9) of the *oesophagus* is highly folded; at places the foldings give rise to highly complex racemose glands which open into the lumen of the oesophagus through inconspicuous ducts. Most of the folds are characterized by the presence of a thick layer of stratified epithelium at their tips, and a number of large distended goblet-cells along their sides. The goblet-cells are most numerous in the deeper folds, being two, three, or several layers deep, while in the superficial folds they are usually one, or at most two layers deep. Some of the smaller folds do not show this differentiation into epithelial and goblet-cells but are covered entirely with goblet-cells. Taste-buds are also present at the tips of some of the folds. The *rete mucosum of Malpighii* is absent, while the *stratum Malpighii* is present but inconspicuous. The *basement membrane* forms a very thin layer. Of the folds forming the racemose glands of the oesophagus, only a few are tipped with stratified epithelial cells,

while the rest are lined either by columnar cells with basal nuclei, or by goblet-cells.



TEXT-FIG. 8.—A longitudinal section of the roof of the pharynx. × 325.

bas.mem., basement membrane; *ct*[1]., connective tissue cell; *g.c.*, gustatory cell; *long.mus.*, layer of longitudinal muscle fibres; *muc.gl.*, mucous gland; *muc.m.*, mucous mother cell, *ret.M.*, rete mucosum of Malpighii; *str.epth.*, stratified epithelium; *str.M.*, stratum Malpighii; *sub-muc.*, sub-mucosa; *sust.*, sustenticular cell; *t.*, taste-bud; *V.*, vein; *ves.*, vesicular cells of adipose tissue.

The *sub-mucosa*, as in the buccal cavity and the pharynx, is considerably reduced by the growth of the *muscularis* which consists of both striated and unstriated fibres arranged into an inner longitudinal and an outer circular layer. The *serosa* forms a fairly thick layer of connective tissue and is penetrated

at places by small blood-vessels as they enter the wall of the oesophagus.



TEXT-FIG. 9.—A transverse section of the oesophagus (serosa not shown). × 50.

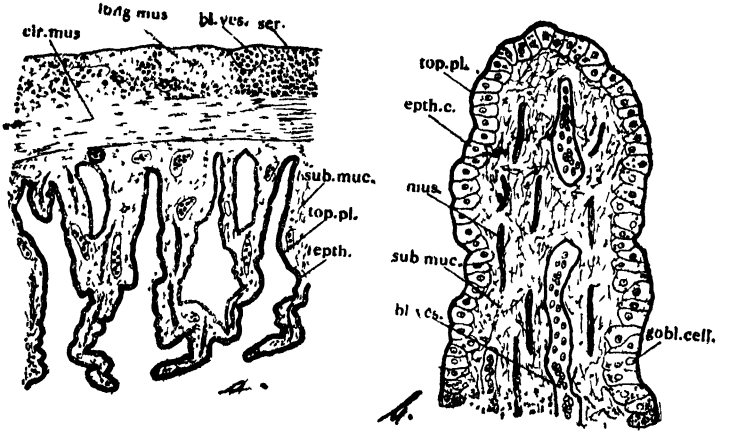
bl.cap, blood capillary, *cir.mus.*, bundles of circular muscle fibres, *col.c.*, columnar cells; *long.mus.*, bundles of longitudinal muscle fibres, *muc.gl.*, mucous gland; *l.oes.gl.*, lumen of the so-called racemose gland of the oesophagus; *str.epth.*, stratified epithelium; *sub.muc.*, sub-mucosa, *t.*, taste-bud.

The intensely folded mucosa, a well-developed striated musculature and an abundance of mucus-producing goblet-cells in the pharynx and the oesophagus along with the racemose glands in the latter form the leading features of the histology of these two regions.

5. *The Intestinal Bulb.*

Except for the honey-combed appearance of the mucosal folds in the proximal part, the various parts of the *bulb* resemble one another in their histological details.

The *mucosa* (Text-figs. 10*a*, *b*) consists only of the lining epithelium supported on a very thin *basement membrane*. The inconspicuous *stratum Malpighii* in the oesophageal region is altogether absent here. The epithelium is unstratified and consists of a single layer of more or less columnar cells topped by a distinct wavy border called the *top plate*. The multicellular gastric glands found in the stomach of other fishes are absent in this fish, thus clearly indicating the absence of a true stomach. A few goblet-cells, however, appear here and there in the epithelium.



TEXT-FIG. 10.—Intestinal bulb of *Labeo rohita* (Ham.).

a. Transverse section of the cardiac region ×75; *b*. Mucosal fold ×470.

bl.ves., blood-vessel; *cir.mus.*, layer of circular muscle fibres; *epth*, epithelial layer; *epth.c.*, epithelial cell; *gobl.cell.*, goblet-cell; *long.mus.*, layer of longitudinal muscle fibres; *mus.*, bundles of muscle fibres; *ser.*, serosa; *sub.muc.*, sub-mucosa; *top.pl.*, top plate.

The *sub-mucosa* is reduced still further and contains loosely arranged bundles of unstriated muscle fibres.

The *muscularis* consists of unstriated fibres arranged in an inner circular and an outer longitudinal layer. The *serosa* forms a very thin layer.

6. *The Intestine.*

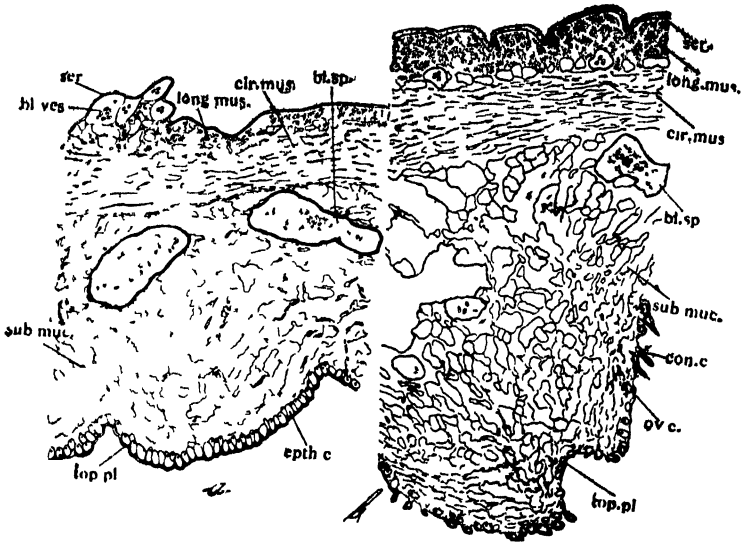
The *mucosa* (Text-fig. 11*a*) of the *intestine* is relatively simple, the folds are low and unbranched. The epithelium consists of small oval cells, interspersed with goblet-cells. The *top-plate* covering the epithelium of the intestinal bulb is continued into this region. The intestinal villi found in other fishes are absent in Rohu.

The *sub-mucosa* consists of loosely arranged fibres forming large meshes with blood-capillaries in them. Interspersed among the strands are a few connective tissue nuclei. There is no sign of a central lacteal, so that the folds are definitely not villi. In view of the fact that the muscularis mucosa is absent, lacteals homologous with those found in the mammalian intestine could not exist in Rohu, since this layer forms part of the wall of these structures. It is possible that the spaces in the sub-mucosa serve as lacteals in this fish.

The *muscularis* consists of an inner thick layer of circular fibres and an outer thin layer of longitudinal fibres.

7. *The Rectum.*

The histological details of the *rectum* (Text-fig. 11*b*) are similar to those of the intestine except for a second type of cells met with in the epithelium. These latter are narrow and



TEXT-FIG. 11.—Intestine and Rectum of *Labeo rohita* (Ham.).

a. Transverse section of intestine ×220; *b*. Transverse section of rectum ×220.

bl.sp., blood-space, *bl.ves.*, blood-vessel; *cir.mus.*, layer of circular muscle fibres; *con.c.*, conical cell; *epth.c.*, epithelial cells; *long.mus.*, layer of longitudinal muscle fibres; *ov.c.*, oval cell; *ser.*, serosa, *sub.muc.*, sub-mucosa; *top.pl.*, top plate.

elongated and have their distal ends hanging freely in the lumen of the rectum. They may be termed *conical cells* and possibly serve to increase the absorptive surface of the rectum.

The epithelium in the various regions of the alimentary canal is thus disposed into variously arranged folds. The simple longitudinal folds of the posterior part of the intestinal bulb, the intestine, and the rectum disappear on distention, and probably provide for the enlargement of their cavities, for the accumulation of the semi-digested food in the posterior part of the bulb and for the accumulation of the faeces in the intestine and the rectum. The highly branched folds of the pharynx and the oesophagus along with the complicated folds of the anterior part of the bulb are probably related to an increase in the secretive area of these regions of the alimentary canal, while the enormous length of the intestine serves to increase its absorptive area.

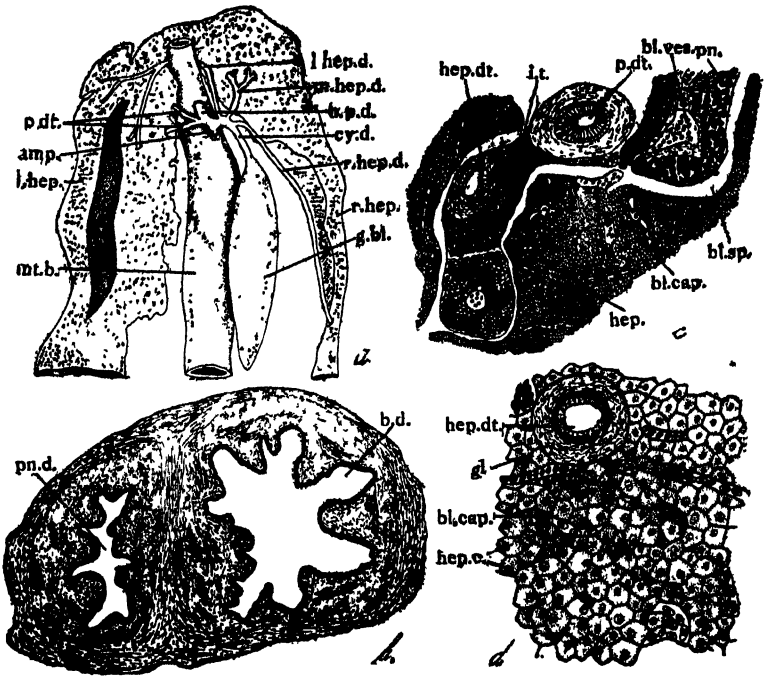
The Glands of the Alimentary Canal.

1. *The Liver.*

The *liver* (Text-figs. 1, 2 and 12*a*) is a solid elongated mass, dark brown in colour, consisting of two lobes: a narrow elongated *right lobe* and a broad *left lobe*, each extending on its side of the intestinal bulb and occupying a considerable area of the abdominal cavity. The two lobes are not discrete all along their length but meet to form transverse connections with each other at *three* places: (1) at their anterior ends (Text-fig. 12*a*), where they lie on the ventral side of the cardiac region of the intestinal bulb and form a common *anterior median lobe* attached to the posterior face of the transverse septum; (2) about the middle of their length (Text-fig. 2), where they meet to form a *middle connecting lobe* on the dorsal side of the intestinal bulb just where the cardiac and pyloric regions pass into each other; and (3) at their posterior ends (Text-fig. 2), where they join across the ventral surface of the pyloric region of the bulb where it makes a curve to pass into the anterior part of the intestine; at this place the liver forms a more or less crescentic *posterior median mass*, extending beyond the limit of the bulb. Each lobe has several irregular subdivisions, the most prominent of which is an appendicular process of the left lobe (Text-fig. 2), lying on the ventral surface of the cardiac portion of the bulb. The left lobe presents shallow depressions on its ventral aspect into which fit the coils of the intestine; such depressions are absent on the right lobe.

Wedged in between the right lobe of the liver and the cardiac portion of the bulb, and partly covering the dorsal surface of the latter lies an elongated thin-walled sac, the *gall-bladder* (Text-figs. 2 and 12*a*), which is about three inches in length and about three-fourths of an inch at its maximum diameter, thus giving it a club-shaped appearance. A comparatively broad thin-walled *cystic duct* leaves the antero-ventral end of the gall-bladder, and runs forwards between the right hepatic lobe and the intestinal bulb for a distance of about half an inch, where it

receives the *right hepatic duct* from the right hepatic lobe. The cystic duct now runs transversely for a short distance and receives



TEXT-FIG. 12.—Alimentary canal of *Labeo rohita* (*Ham.*).

a. Dorsal view of liver and intestinal bulb showing the hepatic and pancreatic ducts $\frac{4}{7}$; *b*. Transverse section of bile and pancreatic duct enclosed in a common sheath ×15. *c*. Transverse section of the liver showing hepatic and pancreatic tissues ×110; *d*. Transverse section of the liver showing the hepatic tissue ×360.

amp., ampulla; *b.d.*, lumen of the bile-duct; *b.p.d.*, common bile and pancreatic duct; *bl.cap.*, blood capillary; *bl.sp.*, blood space; *bl.ves.*, blood vessel; *cy.d.*, cystic duct; *g.bl.*, gall-bladder; *gl.*, glycogen granules; *hep.*, hepatic tissue; *hep.c.*, hepatic cell; *hep.dt.*, hepatic ductule; *i.t.*, islet tissue; *int.b.*, intestinal bulb; *l.hep.*, left hepatic lobe; *l.hep.d.*, left hepatic duct; *m.hep.d.*, median hepatic duct; *p.dt.*, pancreatic ductules; *pn.*, pancreatic acinus; *pn.d.*, lumen of the pancreatic duct; *r.hep.*, right hepatic lobe; *r.hep.d.*, right hepatic duct.

the *median hepatic duct* from the median hepatic lobe and the *left hepatic duct* from the left hepatic lobe. The right hepatic duct leaves the liver a long distance behind its place of entry into the cystic duct, and runs along the mesial margin of the right lobe of the liver. The median hepatic duct is short and joins the cystic duct immediately after leaving the liver, while the left hepatic is elongated like the right hepatic; it leaves the liver at

the anterior end of the left hepatic lobe, runs obliquely across the ventral surface of the commencement of the cardiac portion of the bulb and comes to lie on its right side to open into the cystic duct. The three ducts are formed by the union of several smaller hepatic ductules imbedded in the substance of the liver. After receiving the three hepatic ducts, the cystic duct follows a slightly oblique course and runs forwards for a short distance as the ***bile-duct*** on the roof of the bulb before it opens into its lumen just at its commencement. The short bile duct runs along its entire length side by side with the ***pancreatic duct.*** In fact, the two ducts are enclosed in a common sheath (Text-fig. 12*b*), and are covered over dorsally by the hepatic portal vein; they enter the right side of the roof of the bulb within which they run as two separate ducts and open into the lumen of the bulb by two separate openings lying close together, the opening of the bile-duct being situated at the tip of a raised papilla and that of the pancreatic duct being situated on one side of the bottom of the papilla (Text-fig. 5)—a condition essentially resembling that found in *Amiurus* (Bridge, 1904).

The bile is a slightly greenish, transparent liquid which gives its colour to the gall-bladder.

2. *The Pancreas.*

The ***pancreas*** is apparently absent in Rohu, but is really present as a diffuse mass scattered more or less all over the visceral cavity and also imbedded within the substance of the liver. It is found, firstly, as a perivascular tissue surrounding the finer branches of the blood-vessels ramifying in the adipose tissue attached to the coils of the intestine. Because of the large quantity of the adipose tissue present, the elements of the pancreatic tissue are not easily observed on a macroscopic examination but can be easily recognized in sections. Secondly, a considerable portion of the pancreas is imbedded within the substance of the liver accompanying the ramifications of the portal vessels and the hepatic artery (Text-fig. 12*c*). It is also found imbedded in the substance of the spleen around its smaller blood-vessels. We can thus distinguish two parts of the pancreas: (*a*) an ***intra-hepatic part***, and (*b*) an ***extra-hepatic part.***

Hill (1926), from an examination of a large number of Teleostean and Ganoid fishes, has concluded that the pancreas may be wholly or partly diffuse, the diffuse mass being scattered more or less all over the visceral cavity, and that the portal vessels frequently carry pancreatic tissue along with them even into the substance of the liver. Macallum (1896) had previously described very similar relations of the pancreas in *Acipenser*, *Amia* and *Lepidosteus*, which are confirmed by Hill's observations. Gulland (1898) has also described similar relations of the pancreas in *Salmo*. Macallum (1884) has described the pancreas in *Amiurus* as being imbedded in the liver around the interlobular veins. Smallwood and Derrickson (1934) have described the pancreas in *Cyprinus carpio* as a complex diffused mass simply wrapped up within the liver-tissue. The diffuse

condition of the pancreas seems to be characteristic of most of the Osteichthyes.

A pair of short and narrow pancreatic ductules (Text-fig. 12*a*) formed by the union of several smaller ductules leave the anterior part of the left hepatic lobe, run transversely for a short distance on the dorsal wall of the bulb and finally unite to form the single *pancreatic duct* running alongside the bile-duct, both being enclosed within a common sheath. Before the pancreatic duct is thus ensheathed it enlarges to form a distinct posterior *ampulla*, which probably serves as a reservoir for the pancreatic juice.

Stohr (1893), Goeppert (1893) and Languesse (1894) agree that three pancreatic *anlagen*, one dorsal and two ventral, appear in the larval teleosts. According to Stohr and Goeppert, who studied the condition in the trout, the dorsal and right ventral buds fuse, while the left ventral bud remains small. The dorsal duct atrophies but the two ventral ducts unite together. Smallwood and Derrickson (1934), who studied the condition in *Cyprinus carpio*, have described the origin of pancreas not from one dorsal and two ventral primordia, but from the undifferentiated cells branching off from the right liver duct and extending dorsally over the intestine.

The Histology of the Glands of the Alimentary Canal.

1. *The Liver.*

A microscopic examination of the *liver* (Text-figs. 12*c* and *d*) shows that it is made up of regular polygonal cells, the cytoplasm of which is highly granular and the large rounded nuclei contain one or more nucleoli. There is no definite arrangement of the liver cells into lobules, as is the case in the mammalian liver. A close network of hepatic capillaries recognizable in sections by the presence of blood-corpuscles, supplies the liver-tissue. Scattered in the liver-tissue are very slender hepatic ductules which join together to form hepatic ducts that come out of the liver, one from each lobe. Each ductule (Text-figs. 12*c* and *d*) is lined with a single-layered cubical epithelium, the cells of which have large nuclei; outside the epithelium there is a connective tissue sheath, which acts as a support for the ductules. Some of the hepatic cells are seen to be filled with granules of glycogen (Text-fig. 13*a*); glycogen formation appears to begin in the centre of the cell, since in none of the cells does the periphery show any traces of glycogen.

The *hepatic ducts* are similar to the hepatic ductules in their general structure but are lined by columnar epithelium, outside which the wall is formed of fibrous and elastic tissues. The inner lining of the *bile-duct* is thrown into a number of folds (Text-fig. 12*b*) and is lined with columnar epithelium. Outside it the wall is formed of fibrous, muscular and areolar tissues. The *gall-bladder* (Text-fig. 13*b*) is lined with columnar epithelium, which is surrounded on the outside by fibrous, muscular and elastic tissues.

2. *The Pancreas.*

The *pancreatic tissue*, readily distinguishable from that of the liver, consists of large polyhedral cells (Text-figs. 12*c* and 13*c*), aggregated to form lobules or acini. These acini surround the ramifications of the portal vessels or the branches of the hepatic artery. Each glandular cell in an acinus has a characteristic structure: the rounded nucleus with a definite nucleolus is situated on one side of the cell (excentric), while the rest of the cell shows a number of spherical compartments, like a series of bladders or a bunch of grapes not overlapping one another. These are the secretory granules and are coloured an intense red by Mallory's stain. In addition to the pancreatic acini, a few irregular groups of cells are readily distinguished in the hepatic tissue since they take up a lighter stain than the other cells. These are the *islets of Langerhans*. In some cases, they lie alongside the pancreatic tissue loosely attached to its acini, while in other cases the pancreatic tissue penetrates the tissue of these islets; this is simply due to the diffused condition of the pancreas, which during development invades or becomes attached to other organs of independent function. The islet-tissue is confined to the intra-hepatic portion of the pancreas, since no such tissue has been observed in the diffuse extra-hepatic pancreas *either* in the adipose tissue of the body-cavity *or* in the splenic tissue. The cells of the islet-tissue are more or less polyhedral in shape, and do not show the characteristic secretory granules of a pancreatic cell. Two kinds of cells can be distinguished in the islet-tissue according to the size and staining reaction of their nuclei: the first kind of cells are more numerous and form the bulk of the islet-tissue; their nuclei are smaller and rounded, and stain darkly; the second type of cells are small in number and their nuclei are large and oval, and stain lightly.

Scattered within the liver-tissue in close proximity to the pancreatic tissue are the *pancreatic ductules*, which are easily distinguished from the hepatic ductules by their lining of tall columnar cells (Text-fig. 12*c*).

The *pancreatic duct* (Text-fig. 12*b*) in its general structure is similar to the bile-duct, but has a narrow lumen.

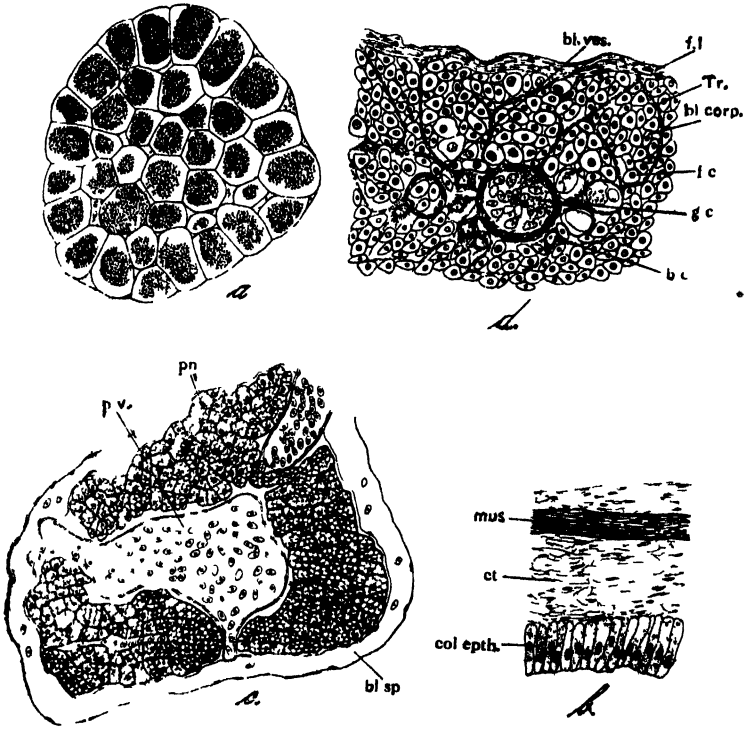
The Ductless Glands.

1. *The Spleen.*

The *spleen*[1] in *Labeo rohita* does not form a single piece, but consists of a large number of distinct lobes, dark red in colour,

[1] Rennie also found accessory spleens in *Lophius*. These appear to be common also in the skate, where two or three minute examples may be seen in a single fish. *Quart. Journ. Micr. Sci.*, XLVIII, p. 387 (foot-note), 1905.

which are scattered in the adipose tissue surrounding the gut (Text-fig. 1). Most of the lobes are aggregated together in a shallow depression on the ventral surface of the left hepatic lobe in close proximity to the intestinal bulb. Here the splenic



TEXT-FIG. 13.—Liver, Gall-bladder, Pancreas and Spleen of *Labeo rohita* (Ham.).

a. Hepatic cells containing glycogen ×470; *b*. Transverse section of the wall of the gall-bladder ×420; *c*. Pancreatic acini from a transverse section of the liver ×420; *d*. Transverse section of the spleen ×400.

b.c., branched cell; *bl.corp.*, blood-corpuscle; *bl.sp.*, blood-space; *bl.ves.*, blood-vessel; *col.epth.*, columnar epithelium; *ct.*, connective tissue; *f.c.*, flat cell; *f.l.*, fibrous layer; *g.c.*, a multinucleated giant cell; *mus.*, muscular layer; *pn.*, pancreatic tissue; *p.v.*, portal vein; *Tr.* trabeculae.

lobes form a more or less elongated mass, the component lobes being separated from each other by the intervening adipose tissue. The lobes vary in shape and size; those on the ventral surface of the hepatic lobe are the largest and are irregular in shape, while those scattered in the adipose tissue surrounding the coils of the intestine are amongst the smallest, though irregular in shape.

Histology of the Spleen.—Each lobe of the spleen (Text-fig. 13*d*) is invested with a fibrous investment which sends its strands or trabeculae inwards and divides the whole gland into a number of lobules. Each lobule is composed of a close network of reticular tissue containing flattened and branched cells along with a large number of blood-corpuscles. In some of the smaller meshes of the reticular tissue is found a single large cell of irregular shape containing a large number of nuclei. These nuclei are very large in size, being more or less oval in shape, and have a lightly staining nucleoplasm. The nuclei of the flattened cells forming the great bulk of the splenic tissue are smaller in size, round in shape and stain deeply. The branched cells are fewer in number and are connected by branches with one another and assist in the formation of the network. Small blood-vessels frequently occur in the glandular tissue. Scattered here and there within the glandular tissue are also found groups of large irregular granules. These granules are of very common occurrence and cannot be called artefacts or foreign matter that may have entered into the gland tissue. The exact nature of these granules is still uncertain.

Imbedded in the tissue of the gland itself, as well as in the accompanying adipose tissue are found strips of pancreatic tissue investing a small blood-vessel, a feature which has so far not been described in any other bony fish. This association of the pancreas with the splenic tissue appears to have been brought about only secondarily because of the diffused character of the former.

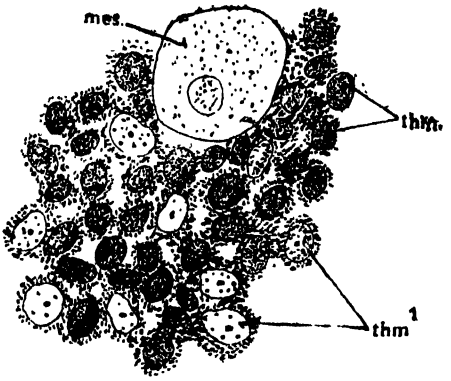
2. *The Thyroid.*

The *thyroid* is a diffuse mass of glandular tissue lying in close association with the connective and lymphoid tissues surrounding the ventral aorta in the region of the first afferent branchial arteries. It cannot be easily recognized on a macroscopic examination, but a microscopic examination shows the gland to be made up of a few scattered, more or less rounded, vesicles lined with cubical epithelial cells, the cell-boundaries of which are not very sharp but the nuclei stain deeply.

3. *The Thymus.*

The *thymus* is an elongated strip of glandular tissue, about 2·0 cm. long and 0·25 cm. broad in a specimen about eighteen inches long, lying obliquely on either side in the region of the first and second vertebrae on the postero-dorsal surface of the inferior pharyngeal bone of the fifth arch. Its posterior end lies just in front of the large mass of the head-kidney, while its anterior end which is uppermost almost reaches the postero-ventral edge of the exoccipital bone. The gland can be easily

exposed by removing the muscles of the body-wall behind the triangular posterior vertical portion of the cleithrum.



TEXT-FIG. 14.—A transverse section of the thymus. ×600.

mes., a large thymus cell with distinct cell boundary; *thm.*, thymus cells with indistinct cell boundaries. Areas shaded lightly are the thymus cells with distinct cell boundaries.

Histology of the Thymus.—The *thymus* (Text-fig. 14) consists of cells with indistinct cell-boundaries, little cytoplasm, and small, rounded, deeply staining nuclei containing irregular chromatin masses. Scattered among the darkly stained thymus cells are others with distinct cell boundaries and large, oval, lightly staining nuclei. These correspond to the mesoderm cells of Deansly (1928), a few of which grow to a very large size. Blood-vessels ramifying throughout the thymus tissue and sometimes aggregations of blood-corpuscles are found in masses amongst the thymus cells. The concentric corpuscles of Hassal are apparently absent.

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ARTICLE No. 1.

Post-Embryonic Development of the Respiratory System of *Dialeurodes eugeniae* Maskell (Homoptera, Aleurodidae) together with Preliminary Observations regarding the Mechanism of Respiration in the different Instars

By R. RAKSHPAL.

(*Communicated by Dr. B. Prashad.*)

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INTRODUCTION.

The immature members of the family Aleurodidae lead a peculiar mode of life in that they remain attached to the leaves by their ventral surfaces; they have therefore developed a few peculiar features in their respiratory organs and mechanism of respiration. This paper is an attempt to give a complete account of the post-embryonic development of the respiratory organs of two Aleurodids and to record a few observations on the mechanism of respiration in the various instars.

Although a few workers had previously given brief accounts of the respiratory organs in white-flies, a complete account of the post-embryonic development of the respiratory system of *Dialeurodes dissimilis* Q. & B. was first given by Roonwal (1935). As I have found a number of new structures showing further peculiarities in the development of the respiratory system, I am giving here an account of my observations.

Development of the respiratory system of *Dialeurodes eugeniae* Maskell.

1. *Spiracles.*

Number.—In a newly hatched larva, the spiracles cannot be seen, but as the larva grows and becomes a fully developed first instar, the four pairs of spiracles (Text-fig. 1) are easily visible. In the second instar (Text-fig. 2) the first, second, and fourth pairs of spiracles become further developed, but the third pair begins to atrophy, *i.e.*, the spiracular trachea which is open in the first instar begins to close and closes completely by the time the second instar is fully developed. Consequently, in the late second instar or early third instar, only three pairs of spiracles remain. As the third instar grows, a new third pair of spiracles makes its appearance and, in the later stages of the third instar, it becomes as fully developed as the other three pairs. This new third pair of spiracles lies a little posteriorly to the original atrophied pair. Thus in the fully developed third instar the full number of four pairs of spiracles is present, and this number is retained in the fourth instar (Text-fig. 4). This replacement is in conformity with the observations recorded by Roonwal (1935) in *D. dissimilis*.

Position.—In the first instar (Text-fig. 1), the first pair of spiracles is situated on either side of the mouth, a little posteriorly to the first pair of thoracic legs. The second pair of spiracles is situated just posteriorly to the second pair of thoracic legs. The third pair of spiracles lies a little posteriorly to the first abdominal segment. The fourth pair of spiracles is situated in the last abdominal segment on either side of the vasiform orifice, but a little posteriorly to it.

In the second instar (Text-fig. 2) the first pair of spiracles moves a little forward and comes to lie about the middle of the thoracic breathing-fold, *i.e.*, at the base of the first pair of thoracic legs in the prothorax. The second pair of spiracles shifts behind and comes to lie between the last two pairs of thoracic legs, *i.e.*, at the posterior margin of the mesothorax. The third pair of spiracles, though beginning to close, similarly shifts behind and comes to lie a little posteriorly to its original position in the first instar, *i.e.*, on the posterior margin of the first abdominal segment. The position of the new third pair of spiracles can also be made out at this stage and lies about the middle of the third abdominal segment. The fourth pair of spiracles moves a little anteriorly and lies one on each side of the vasiform orifice.

In the third instar (Text-fig. 3) the first pair of spiracles lies more or less at the same place as it does in the second instar, but the second pair of spiracles moves still more posteriorly and comes to lie at the anterior margin of the metathorax. Thus there are no spiracles in the mesothorax. The original third pair of spiracles becomes completely closed, and the place

at which the closing takes place lies about the middle of the second abdominal segment. The new third pair of spiracles which lies about the middle of the third abdominal segment in the second instar, shifts backwards and now comes to lie at the posterior margin of this very segment. The fourth pair of spiracles lies more or less at the same place as it does in the second instar, *i.e.*, on both sides of the vasiform orifice. The fourth pair of spiracles is best developed and is slightly bigger in size than the others.

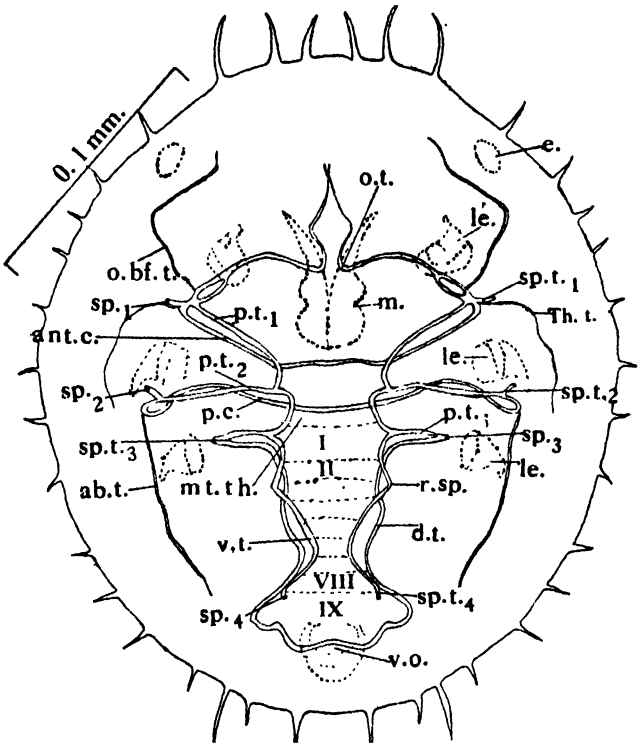


Fig. 1.—The respiratory system of the first instar larva of *D. eugentae* from the ventral side. *ant.c.*, anterior commissural trachea; *ab.t.*, abdominal trachea; *d.t.*, dorsal trunk; *e.*, eye; *le.*, leg; *m.*, mouth; *me.th.*, mesothorax; *o.bf.t.*, ocular breathing-fold trachea; *o.t.*, oral trachea; *p.c.*, posterior commissural trachea; $p.t._1$, $p.t._2$, $p.t._3$, $p.t._4$, palisade tracheae; *r.sp.*, rudiments of the secondary third spiracle; $sp._1$, $sp._2$, $sp._3$, $sp._4$, spiracles; $sp.t._1$, $sp.t._2$, $sp.t._3$, $sp.t._4$, spiracular tracheae; *Th.t.*, thoracic trachea; *v.o.*, vasiform orifice; *v.t.*, ventral trunk; I to IX, abdominal segments.

In the fourth instar (Text-fig. 4) all the four pairs of spiracles are fully developed. The first pair has moved a little anteriorly and comes to lie near the anterior margin of the prothorax.

The second pair has moved a little posteriorly and comes to lie in the metathorax near its anterior margin. The new third pair of spiracles, which is now as well developed as the other spiracles, has also moved a little posteriorly and comes to lie in the fourth abdominal segment near its anterior margin. The fourth pair of spiracles occupies more or less the same place as it does in the second and the third instars. These details of shifting of spiracles have not been described before.

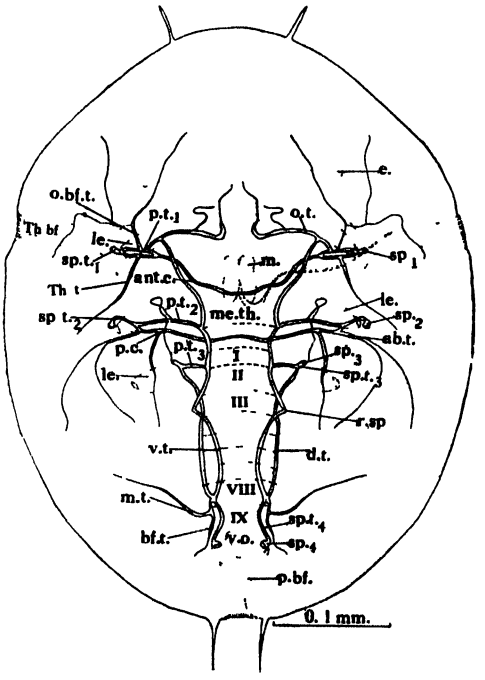


Fig. 2.—The respiratory system of the second instar of *D. eugeniae*, from the ventral side. *bf.t.*, breathing-fold trachea; *m.t.*, mycetomal trachea; *p.bf.*, posterior breathing-fold; *Th.bf.*, thoracic breathing-fold. Other letters as in fig. 1.

Structure.—In the first instar the spiracles just begin to develop, *i.e.*, there is as yet no enlargement of the spiracular tracheae to form any kind of pit or atrium, and therefore the spiracular tracheae open directly to the outside. In the second instar the integument sinks inwards and therefore each spiracular trachea lies at the bottom of the pit-shaped spiracle. In the third instar the spiracles become enlarged although they still remain pit-shaped. In the fourth instar (pupa), the spiracles are fully formed, the largest being the fourth pair. The other

three pairs of spiracles are similar in structure, although subequal in size.

Each spiracle of the fourth pair shows a well-developed structure and may be described as a type. It is more or less bell-shaped (Text-fig. 8); the external or atrial opening is oval in outline and is protected by a cuticular rim or *peritreme*. The atrial opening leads into a bell-shaped atrial cavity, which in its turn leads into the spiracular trachea through a small oval opening. Proximally, the spiracle is produced into a solid, cuticular tail-like process which is possibly supportive in function. There seems to be no mechanism for opening and closing the spiracle which is thus of a simple type.

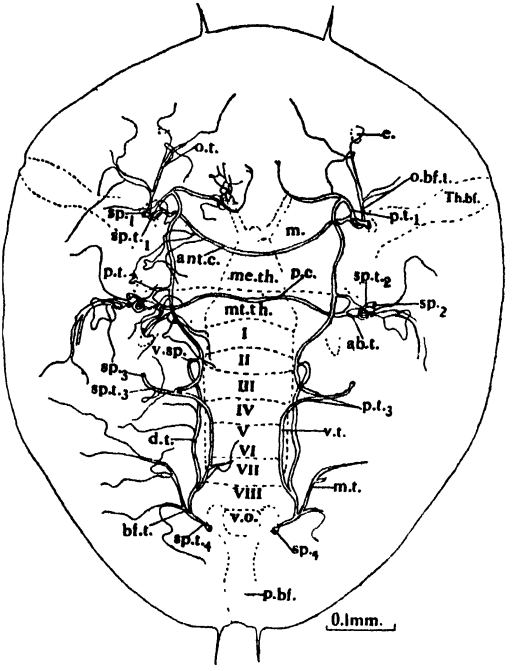


Fig. 3.—The respiratory system of the third instar of *D. eugeniae*, from the ventral side. *v.sp.*, vestiges of the primary third spiracle. Other letters as in figs. 1 and 2.

The development of the spiracles in *D. eugeniae* gives an idea of the evolution of the spiracles. In its simplest form the spiracle (Text-fig. 5) represents a primitive tracheal invagination leading from the integument into the trachea. Spiracles of this kind are found in the first instar of *D. eugeniae*; and form the simplest kind of the open type of spiracle. Later on the primary tracheal aperture becomes slightly sunk so as to lie in a

depression of the integument. The spiracle (Text-fig. 6) thus becomes a pit-shaped chamber, the (atrial) cavity of which opens to the exterior through the atrial orifice, and leads into the trachea by the primitive tracheal orifice. Spiracles of this type are found in the second and the third instars of *D. eugeniae* and represent a more highly developed type than the first. Later on, the atrial orifice becomes protected by a cuticular rim or peritreme (Text-fig. 8), which is found in the pupa. This is a still more highly developed stage. In some cases a further elaboration takes place and a mechanism for opening and closing the spiracle is developed, but this mechanism is not developed in this species.

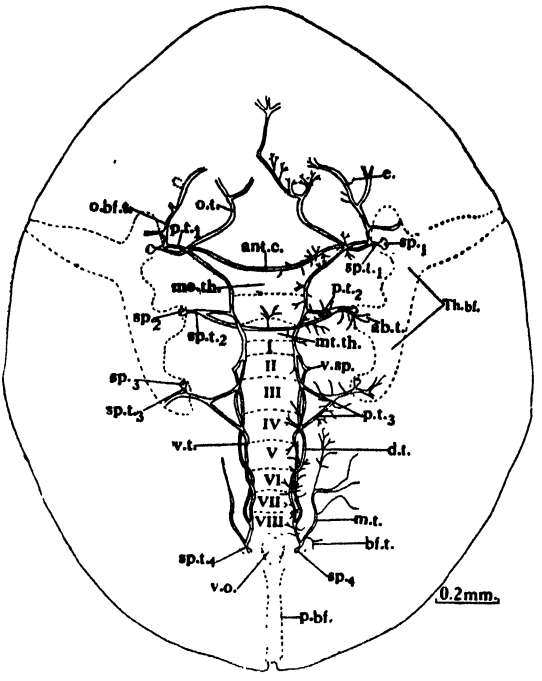


Fig. 4.—The respiratory system of the male pupa of *D. eugeniae*, from the ventral side. Lettering as in figs. 1, 2, and 3.

2. *The tracheae and tracheoles.*

Snodgrass (1935) says, 'As the primary tracheal invaginations grow into the body of the insect, they divide at a short distance from their origin into major and minor branches, and eventually ramify to all the tissues'. In general this statement is true as is shown by a study of the development

of *D. eugeniae* and *Aleurodes* sp., but it is not always so simple, as Roonwal and myself have found that there is a closure of a pair of spiracles accompanied by a closure of spiracular tracheae and their subsequent atrophy, and the development of another pair of spiracles instead. The development of the new pair of spiracles and their spiracular tracheae at an entirely new place forms an exception to the general mode of development. Furthermore, I have found that some of the tracheae also change their place of origin.

(A) Tracheal system of the first instar.

The tracheal system consists of the following main trunks which are well developed even in the newly hatched larva (Text-fig. 1).

(i) A pair of ventral longitudinal tracheal trunks,
(ii) A pair of dorsal longitudinal tracheal tunks, and
(iii) Two transversely placed dorsal commissurals.

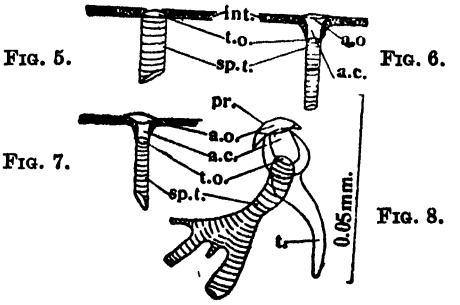


FIG. 5. FIG. 6. FIG. 7. FIG. 8.

Figs. 5, 6, and 7.—Diagrammatic representation of the developmental stages of a spiracle of the first, second, and third instar respectively. Fig. 8.—Fully developed spiracle of *D. eugeniae*. *ac.*, atrial cavity; *a.o.*, atrial opening; *int.*, integument; *pr.*, peritreme; *sp.t.*, spiracular trachea; *t.*, tail; *t.o.*, tracheal opening.

(i) The ventral longitudinal trunks lie one on either side of the body, and extend from the first to the fourth pair of spiracles through which they open to the outside. The fourth spiracle is connected with the ventral trunk through a very small fourth spiracular trachea. From this spiracle the trunk runs forwards, first inwards and then outwards, crossing over the dorsal trunk in the fourth segment. In the third abdominal segment it again bends inwards and crosses over the dorsal trunk in the second abdominal segment. In the first abdominal segment it gives off the third palisade trachea which meets the dorsal trunk lying transversely in this segment. The junction leads to the third spiracular trachea. From the origin of the third palisade trachea the ventral trunk runs medio-anteriorly

and crosses over the posterior transverse commissural in the posterior part of the cephalothorax. In front of this place it runs outwards giving off the second palisade trachea which meets the commissural laterally. The junction leads to the second spiracular trachea. From the point of origin of the second palisade trachea the ventral trunk runs forwards antero-laterally, crossing over the anterior transverse commissural about the middle of the cephalothorax, and as it reaches near the end of the anterior commissural it gives off the very short first palisade trachea to join the anterior commissural, while it itself runs medio-anteriorly towards the mouth. On reaching the mouth it becomes the *oral trachea* and ramifies into the head region. The junction of the first palisade trachea and the anterior commissural leads to the first spiracular trachea (Text-fig. 1).

The other tracheal branches present in the first instar are as follows:—

(*a*) The *ocular breathing-fold trachea* arises from the first spiracular trachea and runs first antero-laterally and then medially to the inner margin of the eye, ramifying into the region between the eye and the mouth, and the region lying externally to the first thoracic leg.

(*b*) The *thoracic trachea* originates from the junction of the first palisade trachea and the anterior commissural trachea, and runs postero-laterally ramifying into the peripheral region of the thorax.

(*c*) The *abdominal trachea* originates from the second spiracular trachea, and runs backwards up to the eighth segment, supplying the peripheral region of the abdomen.

(ii) The *dorsal longitudinal tracheal trunks*.—These are a pair of tracheal trunks originating from the third pair of primary spiracles and extending posteriorly up to the vasiform orifice: these trunks are therefore confined to the area between the first abdominal segment and the vasiform orifice. Each trunk takes more or less the same course as the ventral trunk, and crosses over the ventral trunk in the second, fourth, and eighth segments. Behind the eighth segment, as it reaches beneath the vasiform orifice, it meets its fellow of the opposite side and becomes fused with it. Thus there is no possibility of the presence of a pair of spiracles as described by some other workers (*vide infra*).

(iii) The *dorsal commissural tracheae*.—There are two commissural tracheae, an anterior and a posterior, lying in the posterior part of the cephalothorax; their connections with the ventral trunks have already been referred to.

(*a*) The *anterior dorsal commissural trachea* runs transversely across the body and connects the first pair of spiracles with each other.

(*b*) The *posterior dorsal commissural trachea* similarly forms a transverse connection between the second pair of spiracles.



A photomicrograph of the respiratory system of the male pupa of *D. eugeniae*. Lettering as in figs. 1 and 2. (×60)

As development proceeds, there is little modification in the main tracheal trunks, only the ramifications grow and the system becomes more elaborate.

(B) Tracheal system of the second instar (Text-fig. 2).

(i) The ventral trunk fuses with the dorsal in the eighth abdominal segment, whence it gives off a branch (absent in the first instar) which divides into two, one of which runs backwards and ramifies into the posterior breathing-fold and may therefore be called the posterior *breathing-fold trachea*, while the other known as the *mycetomal trachea*, runs antero-laterally to the margin ramifying into the mycetomal region. Because of the closure of the original third pair of spiracles, both the spiracular and the palisade tracheae in connection with this pair are reduced. The second palisade trachea gives off a small branch which runs first anteriorly and then posteriorly. The first palisade trachea gives off a big branch, the *ocular breathing-fold trachea*, which divides into three branches—the first ramifies into the inner margin of the eye, the second into the outer margin of the eye, while the third goes to the thoracic breathing-fold. The *oral trachea* becomes divided into two branches, which ramify into the head region.

(ii) The dorsal trunks do not show any branching but show a reduction instead, *i.e.*, the transverse portion which lies between the eighth segment and the vasiform orifice (Text-fig. 1) is absorbed. The dorsal trunk fuses with the ventral in the eighth segment.

(iii) The dorsal commissural tracheae.

(*a*) The posterior commissural trachea gives off two branches: the outer is the *abdominal trachea* which, in the first instar, originated from the second spiracular trachea but now originates from the posterior commissural. It divides into two branches: one going to the outer margin of the body and the other to the interior of the body. The inner branch remains single and runs posteriorly.

(*b*) The anterior commissural gives off only the *thoracic trachea* which runs postero-laterally.

Thus in the second instar the ventral trunk and the posterior commissural tracheae show further branching, *i.e.*, they give off five and one branches respectively, the dorsal trunk shows reduction, while the anterior commissural remains unaltered.

(C) The tracheal system of the third instar (Text-fig. 3).

In the third instar a number of important changes take place in the tracheal system. Altogether 40 branches are given off from the main tracheal trunks: 20 from the ventral trunk, 2 from the dorsal trunk, 8 from the posterior commissural

trachea, and 10 from the anterior commissural trachea. An important change is the change of place of origin of the *ocular breathing-fold trachea*, which now originates from the posterior commissural, instead of from the first palisade trachea, as it did in the second instar. There is a reduction of the thoracic trachea, of the third pair of the primary palisade tracheae, and of the third pair of the primary spiracular tracheae, while the third pair of the secondary palisade and the secondary spiracular tracheae show elongation.

(D) The tracheal system of the fourth instar (pupa) (Text-fig. 4 and Plate 1).

In the fourth instar a large number of new branches arise from the main trunks, and at the same time there is a further ramification of the branches already present. These new branches and the ramification of the tracheal system are shown in fig. 4*a*. Thus the ventral trunk gives off 247 branches, the dorsal trunk 20 branches, the posterior commissural trachea 55 branches, and the anterior commissural trachea 30 branches. Thus altogether 352 branches are given off from the main tracheal trunks in a fully developed pupa. The *ocular breathing-fold trachea* originates from the spiracular trachea instead of from the anterior commissural as it does in the third instar. I have studied a number of specimens of the pupa of the species *D. eugeniae* and have found the number of tracheal branches always constant. This confirms the findings of previous authors. Woodworth (1901) found 264 branches in the pupa of *Aleurodes citri*, and Roonwal (1935) found 156 branches in the pupa of *Dialeurodes dissimilis*, but as stated above I have counted 352 branches in *D. eugeniae*.

3. *General conclusions regarding the tracheal system.*

(i) As development proceeds the tracheal system becomes more and more complicated, and the main trunks branch repeatedly.

(ii) During the course of development some branches are totally absorbed, *e.g.*, the *thoracic trachea*, which is well developed in the second instar but is totally absorbed in the third instar.

(iii) Some of the tracheal branches become considerably reduced, *e.g.*, the third pair of primary palisade and spiracular tracheae.

(iv) Some of the tracheal branches, *e.g.*, the *ocular breathing-fold trachea*, change their place of origin in the succeeding instars. In the first and second instars this trachea (Text-figs. 1 and 2) originates from the palisade trachea, in the third instar it originates from the anterior commissural trachea, while in the fourth instar (Text-fig. 4) it originates from the spiracular

trachea. Perhaps this change of position is to provide a better and more copious supply of air to the sensory organs situated anteriorly.

(v) The tracheal branches which run inwards form a network, while those which run outwards towards the margin ramify in a tree-like manner.

(vi) The number of the tracheal branches is constant in a fully developed pupa. This fact is in conformity with the observations of the two other workers, *i.e.*, Woodworth (1901) and Roonwal (1935).

(vii) There is a gradual backward shifting of the tracheal system as shown by Roonwal (1935), a fact supported by my own observations.

(viii) The ventral trunk has the largest number of branches, next comes the posterior commissural trachea, next the anterior commissural trachea, while the dorsal trunk has the least number of branches. As a matter of fact, the dorsal trunk is the least extensive of all the tracheal trunks.

(ix) The main distributing branches always arise either from the palisade or from the spiracular tracheae, *i.e.*, from places nearest the spiracles.

(x) In the first instar the dorsal trunk communicates with the exterior through the primary third pair of spiracles, but as this pair of spiracles closes in the third instar, the dorsal trunk has no direct communication with the exterior after this stage. The dorsal trunk therefore communicates directly with the ventral trunk from which it receives its supply of air. The branches of the dorsal trunk either make loops with the branches of the ventral trunk or run to the interior but they never go to the margin of the body.

(xi) It has been suggested by Roonwal (1935) that perhaps a fifth pair of spiracles exists in *Dialeurodes dissimilis*, just posterior to the vasiform orifice, but in *D. eugeniae* there is no possibility of the fifth pair of spiracles, because both the dorsal trunks fuse with each other beneath the vasiform orifice.

(xii) Heargreaves (1915) suggests that there is an uncertain pair of spiracles in the fourth abdominal segment in *Trialeurodes vaporarorium*. Apparently Heargreaves' mistake arose from the fact that the tracheae in connection with the secondary third pair of spiracles are present even before the spiracles are actually formed, and probably Heargreaves included the secondary pair of spiracles as well as the primary pair in his enumeration.

4. *Development of the breathing-folds.*

The first instar nymph is free-living and moves actively on the leaf of its host plant. As it becomes fully developed it settles down with its ventral side adpressed against the surface of the

leaf. After this attachment, a chitinous covering develops on the dorsal surface of the nymph. This dorsal covering has no opening except the vasiform orifice situated near the posterior end of the nymph. At this stage breathing-folds are altogether absent. Later, another chitinous covering is developed on the ventral surface of the nymph between it and the leaf surface. The ventral covering has only one opening in the head region for the egress of the mouth-parts. Both the coverings grow centrifugally and are closely adherent to the two surfaces of the nymph.

There are three breathing-folds: the two anteriorly placed are known as *thoracic breathing-folds*, while the third posterior one is known as the *posterior breathing-fold*. Their development is as follows:—

In the first instar the breathing-folds are absent and even their future position (Text-figs. 9 and 10) is not well marked. In fact, breathing-folds are not required at this stage, since the dorsal and ventral coverings of the body have not yet developed and so the spiracles open directly to the outside, there being no need for any accessory respiratory structure to help the spiracles to perform their normal function.

In the second instar breathing-folds begin to develop. Since the body coverings grow centrifugally, breathing-folds also grow centrifugally. As the ventral covering grows and reaches the spiracle, small spines are developed on its dorsal surface near the first pair of spiracles. With the growth of the ventral covering, spines also go on growing. On account of these spines the first pair of spiracles always remains in continuity with the external air. At this stage spines are not developed near the other spiracles which therefore cannot function. When the ventral covering is fully developed, finger-like projections develop near the external opening of the fold, *i.e.*, at the place where the spined ventral covering meets the dorsal covering. This is how the thoracic breathing-folds develop. The external opening of the posterior breathing-fold is also marked.

In the third instar the posterior breathing-fold which is Y-shaped is also developed, *i.e.*, small spines are developed on the dorsal surface of the posterior part of the ventral covering, and thus the fourth pair of spiracles also becomes connected with the external air and can perform its normal function. Later on, accessory openings are formed on the dorsal surface of the body of the nymph just opposite the first pair of spiracles, and beneath the vasiform orifice. Chitinous thickenings are developed on the dorsal covering on the surface next to the nymph. Between these thickenings narrow spaces remain and it is through these spaces that the accessory openings get their supply of air.

Thus a fully developed breathing-fold consists of the following parts:—(i) a roof formed by the dorsal body covering, (ii) a floor formed by the ventral body covering, (iii) an external

opening formed between the two coverings, and (iv) an accessory opening formed in the dorsal body-wall of the nymph.

(i) The ventral surface of the dorsal body covering shows chitinous thickenings which are elongated distally and more or less rectangular proximally. Between these thickenings narrow spaces remain and it is through these spaces that the air entering through the external opening of the fold passes into the accessory opening of the nymph.

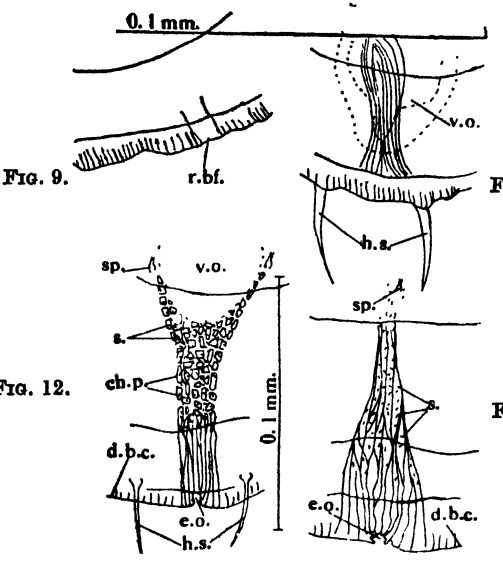


FIG. 9.

FIG. 10

FIG. 12.

FIG. 11.

Figs. 9 and 10.—Rudiments of the thoracic and posterior breathing-folds of the first instar larva of *D. eugeniae*. Figs. 11 and 12.—Thoracic and posterior breathing-folds of the second instar. *ch.p.*, chitinous thickenings; *d.b.c.*, dorsal body covering; *e.o.*, external opening; *h.s.*, hatching spines; *r.bf.*, rudiment of the breathing-fold; *s.*, spines; *sp.*, spiracle; *v.o.*, vasiform orifice.

(ii) The floor of the breathing-fold is beset with small spines distributed all over its surface next to the ventral body-wall of the nymph. On account of these spines a little space remains between the chitinous ventral covering and the ventral body-wall and thus the air entering the external opening of the fold passes through this space into each of the first pair of spiracles. In the early stages the spines are not distributed on the floor of the posterior breathing-fold. Small porous wax-particles are found between these spines.

(iii) The external opening shows finger-like projections named as *teeth* by Singh (1931). In the early stages the opening shows only a few such projections, but as development proceeds they increase in number.

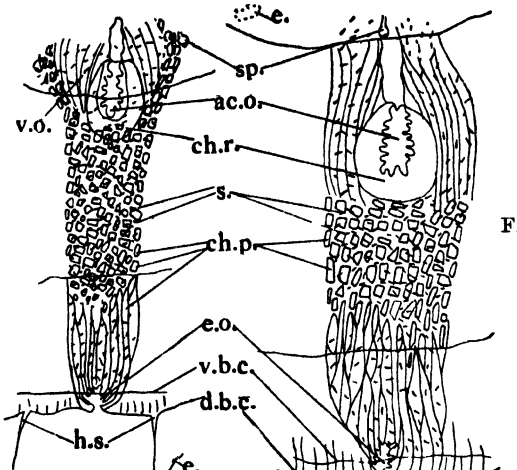


FIG. 14.

FIG. 13.

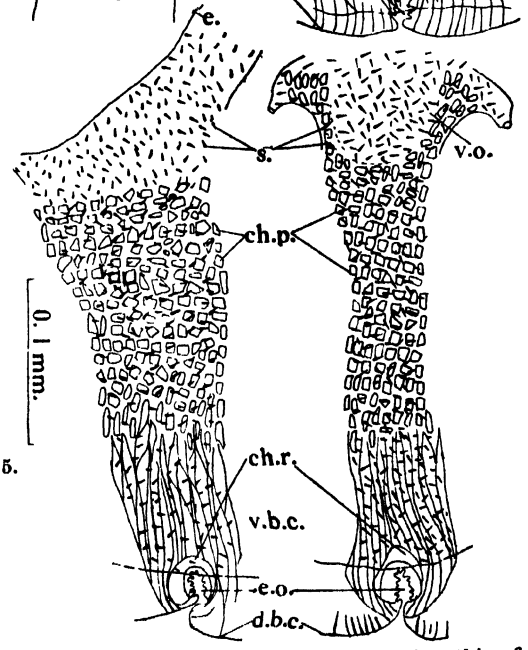


FIG. 15.

FIG. 16.

Figs. 13 and 14.—Thoracic and posterior breathing-folds of the third instar of D. *eugeniae*. Figs. 15 and 16.—Thoracic and posterior breathing-folds of the pupa. ac.o., accessory opening; *ch.r.*, chitinous rim; v.b.c., ventral body covering. Other letters as in fig. 9.

(iv) The accessory openings are situated on the dorsal surface of the nymph, two lying just opposite the first pair of spiracles and one beneath the vasiform orifice. Each opening also shows

a number of finger-like projections like the external opening. As already stated, the accessory openings communicate with the external openings through narrow spaces between the chitinous thickenings in the dorsal body covering.

In the fourth instar the breathing-folds show a few important changes.

The thoracic breathing-folds (Text-fig. 15) become very much wider and elongated, and as their bases become very wide, they extend posteriorly from the prothorax to the fourth segment (Text-fig. 4), thus enclosing the first, second and third pairs of spiracles. The external opening of each fold develops further, *i.e.*, the number of finger-like projections increases and they are guarded by a thick chitinous rim. The accessory openings become closed.

The posterior breathing-fold (Text-fig. 16) embraces in front the fourth pair of spiracles. The external opening of the fold is surrounded by a cuticular rim, and the finger-like projections also increase as in the case of the thoracic breathing-folds. The accessory opening also closes.

5. *Functions of the breathing-folds.*

That the breathing-folds are accessory respiratory organs is shown both by their position and structure. It is through these structures that the spiracles perform their function as otherwise they would remain functionless, since they are covered over by the ventral body covering. As air enters the external openings of the folds the solid particles are retained by the finger-like projections surrounding the opening, thus letting in only filtered air. The floor of the fold is beset with small spines thus leaving sufficient space between the ventral body-covering and the ventral body-wall so that air can reach the spiracles situated on the ventral surface of the body. In between the spines small particles of porous wax are found which allow only filtered air to go to the spiracles. Further, in between the chitinous thickenings in the roof (dorsal body covering) of the fold, narrow spaces remain through which the external opening communicates with the accessory opening. The breathing-folds begin to develop as the ventral covering reaches near the spiracles.

The growth of the breathing-folds is therefore a device to connect an increasing number of spiracles with the external air.

6. *Mechanism of respiration.*

As regards the mechanism of respiration in Insects Wigglesworth (1931) says, 'as a general rule it may be said that the movements are confined to the abdomen as a general rule expiration is active, and inspiration passive'. This description holds also for *D. eugeniae*. The first instar is a free-

living larva and moves about actively on the leaf of the host plant. Being active, it needs a very efficient mechanism of respiration. All the tracheal trunks open directly to the exterior,

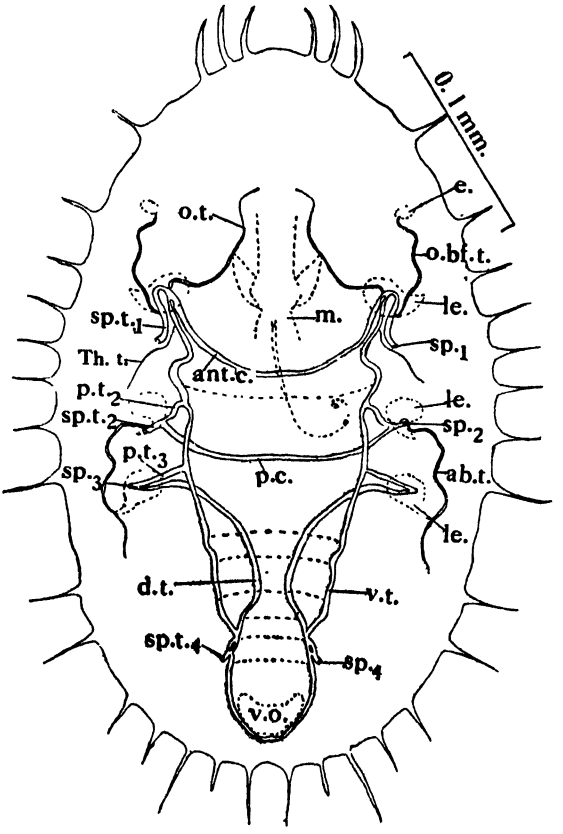
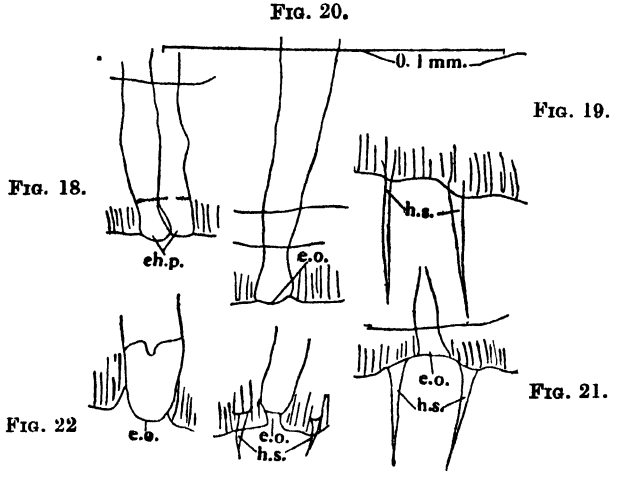


Fig. 17.—The respiratory system of the first instar larva of *Aleurodes* sp., from the ventral side. Lettering as in fig. 1.

and therefore, air enters easily into the tracheal system. The entrance of air is brought about by the pulsation of the posterior portion of the body. There are neither breathing-folds nor accessory openings as these are not needed. As all the four pairs of spiracles are functional, the respiratory system is therefore of *oligopneustic* type (Imms, 1934). After the first instar the nymph becomes adpressed to the leaf and the ventral and dorsal body coverings are developed. Therefore, air cannot enter the tracheal system directly. At this stage the breathing-

folds begin to develop so as to establish a means of communication between the spiracles and the outer air. In the fully developed second instar the thoracic breathing-folds embrace the first pair of spiracles, but the posterior fold does not reach the posterior pair of spiracles. At this stage only the first pair of spiracles can function as it is connected to the external air through the breathing-folds, while other pairs cannot function as they are covered over with the ventral body covering. Since only the first pair of spiracles situated in the prothorax is functional, the respiratory system is of *propneustic* type. In the third instar the nymph becomes further developed, and thus a larger quantity of air is needed, therefore the posterior breathing-



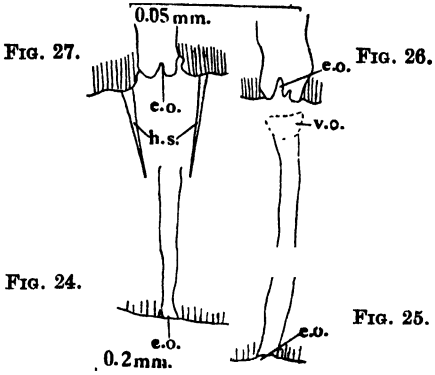
Figs. 18 and 19.—Rudiments of the thoracic and posterior breathing-folds of the first instar larva of *Aleurodes* sp. Figs. 20 and 21.—Thoracic and posterior breathing-folds of the second instar. Figs. 22 and 23.—Distal ends of the thoracic and posterior breathing-folds of the third instar. Lettering as in fig. 13.

fold embraces the fourth pair of spiracles, and accessory openings are also developed. Since both the prothoracic and the posterior pair of spiracles are functional, the respiratory system is of *amphipneustic* type. In the early stages of the fourth instar only the first and the fourth pairs of spiracles are functional and the nymph shows very active (80–90 times per minute) pulsations of the whole body, but in the fully developed pupa the body pulsates only after long intervals. In the pupa all the four pairs of spiracles are functional, so that the respiratory system is again of *oligopneustic* type. At this stage the accessory openings are closed as they are not needed, because all the four pairs of spiracles are functional.

Development of the respiratory system of *Aleurodes* sp.

I have also studied the post-embryonic development of the respiratory system of a species of *Aleurodes* (Text-fig. 17). The general plan of development of the spiracles and the tracheae is similar to that of *D. eugeniae*, but the breathing-folds are ill-developed.

In the first instar the breathing-folds are not developed, but the position of the openings of the thoracic breathing-folds is marked by the presence of a pair of thick chitinous rectangular pieces (Text-fig. 18). In the second instar the anterior breathing-folds begin to develop (Text-fig. 20) but remain very narrow. The posterior fold is still undeveloped (Text-fig. 21). In the third instar (Text-figs. 22 and 23) all the breathing-folds are fully developed, but they remain narrow and reach the first and the last pair of spiracles respectively. In the fourth instar the folds are further elongated but otherwise they are similar to those of the third instar (Text-figs. 24 to 27).



Figs. 24 and 25.—Thoracic and posterior breathing-folds of the pupa of *Aleurodes* sp. Figs. 26 and 27.—Distal ends of the same. Lettering as in fig. 13.

The breathing-folds of *Aleurodes* sp. differ from those of *D. eugeniae* in the following points:—

1. The openings of the breathing-folds never show any kind of finger-like projections.
2. There are neither spines nor wax-particles in the breathing-folds.
3. The breathing-folds are very narrow and ill-developed as compared with those of *D. eugeniae*.
4. The accessory openings are not developed in any of the larval instars.

5. The body of *Aleurodes* sp. is very thin as compared with that of *D. eugeniae*.

Though both the species are found on the same host (*Eugenia jambos*) and nearly at the same time of the year, there are marked differences in the development of the breathing-folds of the two species. These differences are probably due to the following reasons:—

1. In *Aleurodes* sp. there is no ventral body covering except in the pupa, and even there, the covering is very thin, while in *D. eugeniae* a chitinous ventral covering is present in the last three instars.

2. All the instars of *Aleurodes* sp. lie on the under surface of the leaf of the food plant where the stomata are always open, while in *D. eugeniae* all the instars lie on the upper surface. In the absence of a ventral body covering the air either from the atmosphere or oxygen from the stomata passes directly into the spiracles.

3. The dorsal body covering except in a fully developed pupa of *Aleurodes* sp. is very thin, while in *D. eugeniae* this covering is very thick.

4. Sometimes the body of *Aleurodes* sp. bends near the folds and thus the spiracles come in direct contact with air.

5. None of the instars of *Aleurodes* sp. lie in depressions in the leaf of the food plant while the last three instars of *D. eugeniae* lie in such depressions.

MATERIAL AND TECHNIQUE.

The material for the present investigation was collected from *Eugenia jambos* (*jamun*) in April 1939. For the study of tracheal system the specimens were mounted either in glycerine or in euparol. To study the spiracles and breathing-folds, specimens were mounted in canada balsam after dehydrating in alcohol and clearing in xylol. For a study of the mechanism of respiration, living specimens were studied under a low magnification. The drawings were made from the ventral side with the help of a camera-lucida.

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Volume VI, 1940.

ARTICLE No. 2.

On Catfish Spines embedded in the Mesentery of *Ophicephalus punctatus* Bloch.

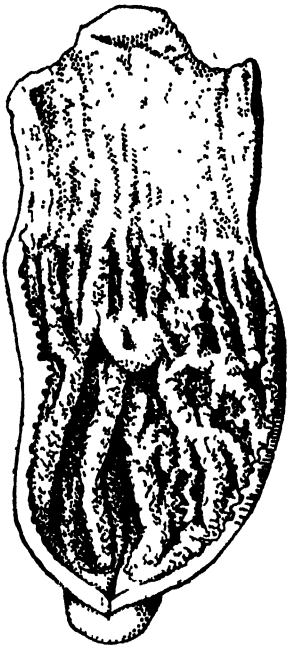
By S. L. HORA *and* J. N. RUDRA.

In February 1939, one of us (J.N.R.) while demonstrating the dissection of *Ophicephalus punctatus* Bloch to his students found certain bony structures in the mesentery of the fish. These structures were sent to the Zoological Survey of India for determination and were found to be portions of pectoral spines of some Siluroid fish, possibly *Mystus gulio* (Hamilton). Later, preparations of the fin-spines of *M. gulio* were made which enabled us to confirm the identification of the portions of spines found in the mesentery of *O. punctatus*.

There are several records of the occurrence of foreign bodies embedded in the tissues of fishes and, in 1922, Gudger brought them together in one article. At the same time he directed attention to a few new instances that had come under his personal observation. On request, he has very kindly supplied to us a list of recent cases (*vide* List of References) which, with the exception of two, we have not been able to consult as the journals in which they appeared are not available in any of the libraries in Calcutta. From the publications consulted by us it seems that Pipe-fish and Eels of different sorts with their pointed bodies, on ingestion by a larger fish, are sometimes capable of boring through the wall of the stomach and thus reaching the body cavity, where they become mummified in the folds of the mesentery. Besides these living objects, Gudger has also recorded the occurrence of the vertebral column of some fish in the mesentery of a Barracuda (*Sphyraena barracuda*) and on the authority of Mr. Vinal Edward noted two instances in which 'the skeleton of fish' was found embedded 'in the meat near the backbone' of a Hake and a Swordfish respectively. How these foreign objects became lodged in their respective places must remain more or less a mystery until, as pointed out by Gudger, careful dissections of such specimens are made by trained anatomists.

In the case of the fish spines found in the mesentery of *Ophicephalus punctatus*, the explanation is very simple. Catfishes have strong spines in their pectoral fins and in some genera the dorsal spine is also well developed. The pectoral spine has a peculiar joint by means of which it can be set immovably by means of a slight downward or forward twist. When irritated these fishes erect their spines and inflict jagged wounds on account of the serrated edges of the spines. It is well known that 'Pelicans which have swallowed the catfish have been known to

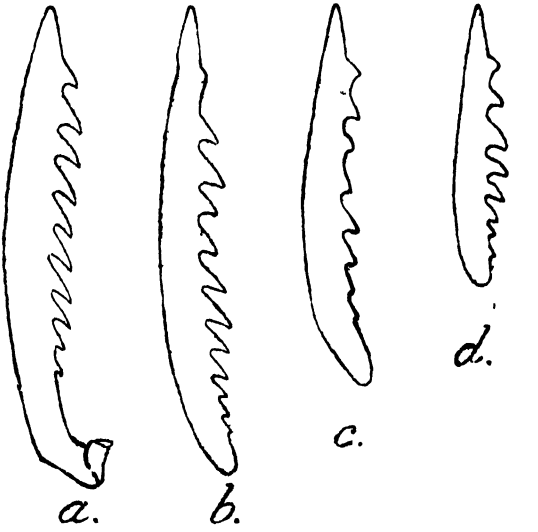
die of the wounds inflicted by the fish's spine. When the catfish was first introduced into the Sacramento, according to Mr. Will S Green, it caused the death of many of the native "Sacramento perch" (*Archoplites interruptus*). This perch (or rather bass) fed on the young catfish, and the latter erecting their pectoral spines in turn caused the death of the perch by tearing the walls of its stomach. In like manner the sharp dorsal and ventral spines of



TEXT-FIG. 1.—Stomach of a specimen of *Ophicephalus punctatus* Bloch opened to show its thick, muscular walls and the prominent folds of the mucosa.

the sticklebacks have been known to cause the death of fishes who swallow them, and even of ducks. In Puget Sound the stickleback is often known as Salmon-killer' (Jordan 1905, p. 179). The position of the spines of *Mystus gulio* in the mesentery of *Ophicephalus punctatus* recalls a somewhat similar encounter between two fishes when the latter must have preyed on the former for food. From the fact that portions of pectoral spines were fully enveloped in mesenteric folds it seems clear that *Ophicephalus* was none the worse for these wounds; this presumed immunity was probably made possible by the highly muscular walls of the stomach and the prominent folds of the mucosa (Text-fig. 1) of *O. punctatus*. The study of eleven spines removed from the mesentery of *O. punctatus* indicates two other important

points. Firstly, the spines are not complete and only in three cases the basal part is present. In most of the spines the basal portion is missing and only the distal half or two-thirds is mummified. The respective lengths of the preserved spines (Text-fig. 2) show that in penetrating through the walls of the stomach they



TEXT-FIG. 2.—Pieces of the pectoral spines of *Mystus gulio* (Hamilton) found embedded in the mesentery of *Ophicephalus punctatus* Bloch.

projected either partly or wholly in the body cavity, for the portions that remained inside the stomach must have been acted upon by the gastric juices and digested; while the portions that projected in the body cavity remained unaffected. Secondly, these mummified spines are very strong and show, as has been remarked by several previous authors, that once lodged in the coelomic cavity no putrefaction or decay takes place and the object remains nicely preserved.

Unfortunately the eleven spines, referred to above, had been removed from their positions and the fish thrown away, so it was not possible to study the stomach walls for scars of wounds. Several specimens of *O. punctatus* have since been examined, but spines were found embedded in the mesenteries of only two in the region of the stomach; each specimen had only one spine. After removal of the mesentery and loose tissues from the outer surface of the stomach wall, one healed up and jagged scar of wound could be seen in the stomach wall of each specimen from the outer side, but on account of the thick folds of mucosa it was not possible to make out any scar from the inner side. These observations confirm the view advanced above that

O. punctatus survives the puncturing of its stomach walls by the spines of *Mystus gulio* from the inner side.

The specimens of *Ophicephalus punctatus*, which harboured the spines, were purchased in February 1939 and March 1940 from the College Street Market in Calcutta and were stated to have been collected from the Salt Lakes. When during the dry season from November to March the waters fall low, large quantities of air-breathing fishes (*Jiol Machh*) of various kinds, including species of *Ophicephalus*, are collected from marshy areas. At this time *Mystus gulio* is also very abundant and basket-loads of it are brought to the Calcutta markets for sale (Hora 1934, p. 132); it is also a very tenacious fish and can even live out of water for several hours (Hora 1935, p. 2).

SUMMARY.

The presence of pectoral spines of *Mystus gulio* (Hamilton) in the mesentery of *Ophicephalus punctatus* Bloch is recorded, and attention is directed to the earlier records of foreign bodies embedded in the tissues of fishes. An explanation as to how the spines became lodged in the mesentery is given and reference is made to certain relevant features in the ecology and bionomics of the two species concerned.

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ARTICLE No. 3.

On Trematodes Collected in Pilibhit (North India).

By B. S. GOGATE.

(*Communicated by Dr. B. Prashad.*)

Family LEPODERMATIDAE Looss, 1901.
Prosthogonimus cuneatus (Rudolphi, 1809) Braun, 1901.

Host: *Francolinus gularis* (Temmnick, 1815).
Location: Bursa fabricii.
Locality: Pilibhit.

Description.—5·26 × 2·97 [1]. Oral sucker 0·265 in diameter. Ventral sucker 0·757 × 0·817, situated at 1·12 from anterior end of the body. Pharynx 0·144 × 0·196. Oesophagus 0·231 long. Testes 0·861–0·901 × 0·760–0·794, separated from each other by 0·57 and situated two-third of their dimensions in the anterior half of the body. Cirrus sac 1·01 × 0 115, sinuous and extending behind the caecal fork but not reaching the ventral sucker. Ovary much lobed, submedian (more on the right side), 1·01 in its long (transverse) diameter and slightly overlapped by posterior border of ventral sucker. Vitellaria follicular, not broken up into clusters, and extending into posterior half of the body. Uterus for the most part post-testicular; uterine coils cross the caeca, and in front of the ventral sucker its terminal portion runs alongside the cirrus sac. Ova 0·0192–0·0269 × 0·0092–0·0130.

Remarks.—In view of the findings of Witenberg and Eckmann (1939) this form is assigned to *Prosthogonimus cuneatus* neglecting slight variations in the dimensions and situations of various structures. The authors referred to, have reduced the number of valid species of the genus to seven, on the ground that 'most of them depend on age or on the state of contraction or individual variations'. They suggest that the species should be distinguished on the basis of: (1) relative sizes of oral and ventral suckers, (2) the character of uterine coils, and (3) the shape and distribution of vitellaria considered relatively. Any attempt to describe a new species on the assumption of host-specificity is further to be abandoned because the same authors record that *Prosthogonimus* are noted for their lack of this specificity and geographical distribution.

[1] All measurements in millimetres.

Family PSILOSTOMIDAE Odhner, 1913.
Psilorchis indicus Thapar and Lal, 1935.

Host: *Alcedo ispida* Linnaeus, 1758.
Location: intestine.
Locality: Pilibhit.

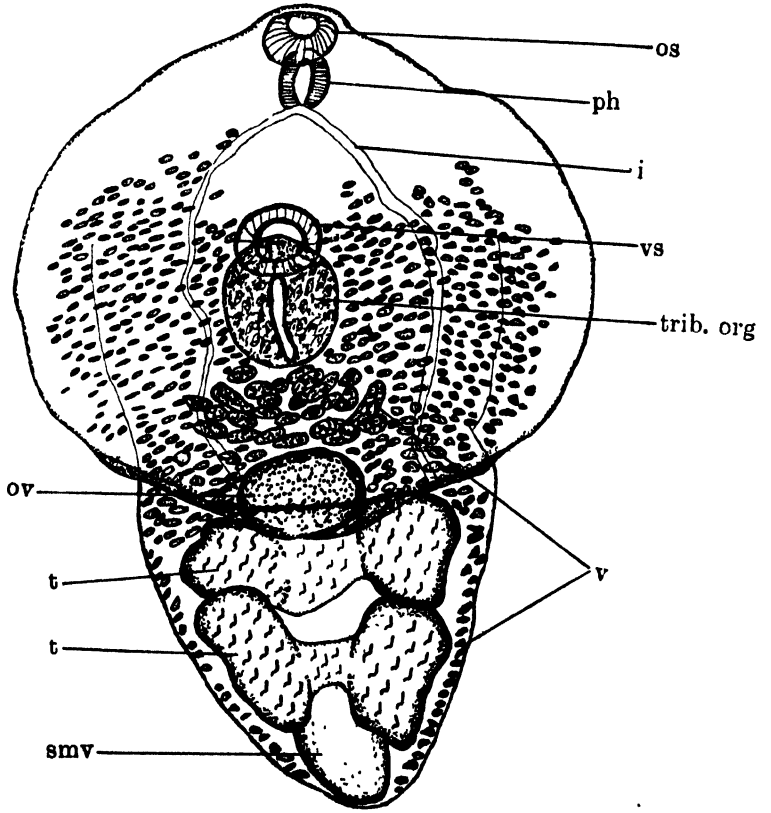
A specimen of this species was obtained from the kingfisher *Alcedo ispida* Linn. The measurements recorded by Thapar and Lal (1935) are given below for comparison; but the variations observed do not appear to the author to be of specific value, more particularly in view of the similarity of hosts.

	Author's measurements.	Thapar and Lal's measurements.
Length ..	8·31	8·57
Breadth ..	1·00	1·17
Cuticle ..	spiny in anterior part of the body.	smooth
Oral sucker ..	0·219×0·243	0·17×0·10
Ventral sucker ..	0·79×0·682	0·75×0·65
Pre-pharynx ..	0·037 long	0·18 long
Pharynx ..	0 121 in diameter	0·18×0·16
Oesophagus ..	0·146 long	0·09 long
Anterior testis ..	0·682×0·336	0·75×0·42
Posterior testis ..	0·707×0·341	0·75×0·36
Cirrus sac ..	0·468×0·195 retort shaped right sided.	
Ovary ..	0·297×0·273	0·41×0·25
Ova ..	0·097–0·195 × 0·048–0·100	0·125–0·130 × 0·08–0·100
Host ..	*Alcedo ispida*	*Halcyon smyrnensis*
Location ..	intestine	intestine
Locality ..	Pilibhit	Lucknow

Remarks.—The absence of cuticular spines in this species may be due either to old age or incomplete observation. In their original records of the species (Thapar and Lal, 1935) and the diagnosis of the genus no description of a cirrus sac is given, though in the key to the species by Lal (1939) it is specifically mentioned. In order to clarify the position both authors were individually requested for the loan of slides without success. It is therefore suggested that the structure surrounding the vesicula seminalis as shown in figure 3 (Thapar and Lal, 1935) and directly observed by the present author is a true cirrus sac. The diagnosis of the genus *Psilorchis* should therefore be emended to include 'spiny cuticle and retort shaped cirrus sac enclosing a voluminous vesicula seminalis'.

Family DIPLOSTOMIDAE Poirier, 1886.
Neodiplostomum gumbudia, sp. nov.

Host: *Milvus govinda* Sykes, 1832.
Location: intestine.
Locality: Pilibhit.



TEXT FIG. 1. **Neodiplostomum gumbudia**, sp. nov., Entire ventral

i., intestine; *os.*, oral sucker; *ov.*, ovary; *ph.*, pharynx; *smv.*, seminal vesicle; *t.*, testis; *trib. org.*, tribocytic organ; *v.*, vitellaria; *vs.*, ventral sucker.

Description.—Total body length 0·926. Both body segments broader than long: Anterior body segment 0·556×0·669, lateral folds absent, lateral margins of the segment meeting ventrally behind tribocytic organ. Posterior body segment 0·370×0·422.

Oral sucker 0·053×0·085. Pharynx 0·058×0·052. Oesophagus absent. Caeca distinct only in the anterior body segment. Ventral sucker 0·068×0·075, approximately half overlapped by tribocytic organ. Tribocytic organ elliptical, 0·137×0·131, situated in middle of the anterior body segment. Ovary transversely oval, 0·098×0·151, situated near the junction of the anterior and posterior body segments, ventrally partly anterior to and partly posterior to the ventral union of lateral margins of the anterior body segment. Testes big and ventrally concave; anterior testis 0·320 and the posterior testis 0·294 in breadth. Vesicula seminalis voluminous; bursa reduced; genital pore subterminal. Vitellaria anteriorly extending as far as the caecal bifurcation and posteriorly and laterally they extend to the end of the body. Vitelline follicles fine and thinly spread out except in the area between the posterior border of the tribocytic organ and the anterior border of the ovary, where the follicles are clustered in the form of thick large sized bodies. Ova not developed.

Remarks.—In its very small size this form differs from all the species of the same genus except *N. biovatum* Dubois, 1937; *N. ellepticum* (Brandes, 1888) La Rue, 1926; and *N. globiferum* Verma, 1936. From *N. biovatum* and *N. globiferum* it is distinguished by the ventral sucker being half overlapped by the tribocytic organ. From *N. ellepticum* it is separated by the absence of lateral folds, the smaller ratio of the posterior body segment length to that of the anterior body segment length, smaller size of the tribocytic organ, marked clustering of the vitellaria between the tribocytic organ and the ovary, and other minor differences.

Family STRIGEIDÆ Railliet, 1919.

Strigea falconis Szidat, 1928.

Host: *Neophron percnopterus* (Linneaus, 1758).
Location: intestine.
Locality: Udaipur (Pilibhit).

Description.—Body 2·183–2·363 long, strongly curved, with tribocytic organ retracted or stretched out of cup shaped anterior body segment. The cup shaped anterior body segment 0·741–0·822×0·914–0·964, separated from the posterior body segment by a deep constriction. Posterior body segment 1·361–1·622×0·718–0·762.

Vitellaria very thickly distributed in both the body segments, consisting of large sized follicles and masking practically the entire anatomy in whole mounts. The measurements given below, except those of eggs and bursa, are taken from sections.

Oral sucker 0·119×0·139. Pharynx 0·066×0·085. Oesophagus not distinct. Ventral sucker 0·186×0·180. Tribocytic

organ with two folds, one dorsal and one ventral, visible outside in the stretched condition through the cup shaped anterior body segment. Ovary 0·220 × 0·255, separated from the anterior testis and situated behind the junction of the posterior body segment with the anterior body segment. Testes partially overlapping each other: Anterior testis 0·357 × 0·192. Posterior testis 0·317 × 0·232. Bursa 0·130 deep, with small genital cone. Ova few in number, 0·065–0·105 × 0·050–0·069.

Acknowledgment.

I have to express my thanks to Mr. L. N. Johri who handed over to me for investigation the trematodes he collected in summer at Pilibhit proper or Udaipur (Pilibhit) and which form the subject of the present paper.

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ARTICLE NO. 4.

A Note on *Cassia javanica* L. and *Cassia nodosa* Ham. with a Key to the Cultivated Tree Cassias.

By V. NARAYANASWAMI.

(*Communicated by Dr. K. Biswas.*)

The commonest sight, during the months of April to June, in Calcutta, especially in the public parks and in a number of private gardens, is that of the two most beautiful of ornamental plants, namely, *Cassia nodosa* Ham. and *Cassia javanica* L. in flower. The numerous clusters of pink flowers and the gracefully spreading and pendulous feathery-leafed branchlets cannot fail to arrest, at once, the eyes of every lover of nature. They resemble each other so very closely in general appearance and in the colour of the flowers that it has become a matter of difficulty for the casual observer to distinguish one from the other.

Cassia javanica L. was the first of the two species to be known to science and Linnaeus published it in the first edition of his *Species Plantarum* in 1753, with the brief description that it was a species with 12 pairs of oblong, obtuse, glabrous leaflets, with its habitat in India. *Cassia nodosa* was first introduced into the Sibpur Botanical Garden in the year 1798 by Francis Buchanan (later Buchanan Hamilton) from Chittagong. Roxburgh published it first in his *Hortus Bengalensis* in 1814 as *Cassia nodosa* Ham. without a description. It was, however, published with a complete description in 1832 in the second volume of the *Flora Indica* by Roxburgh. Hamilton's name was most probably only a manuscript name given to it by Hamilton when it was first sent to his friend Roxburgh for cultivation in the Sibpur Botanical Garden. A noteworthy point about *Cassia nodosa* Ham. is that it has never been collected in a truly wild state either from Chittagong or elsewhere since Hamilton's day.

Two years after the introduction of *Cassia nodosa* Ham. into the Sibpur Botanical Garden, Roxburgh introduced in 1800 another beautiful Cassia, namely, *Cassia bacillus* Gaertn. the seeds of which he obtained from Sumatra through Dr. C. Campbell. This was first published without description in the *Hortus Bengalensis* in 1814 and again with full description in the *Flora Indica*, Vol. ii, p. 337 in 1832. Roxburgh had pictures made of these two plants which are now available in his unpublished Icones in the Sibpur Library. *Cassia bacillus* Gaertn. has since been universally identified with the earliest *Cassia javanica* Linn. and there seems no reason to doubt it.

Roxburgh described the two plants thus:—

Cassia javanica L. (*C. bacillus* Gaertn.)	*Cassia nodosa* Ham.
Stem spiny.	Stem not spiny.
Leaves 8–14 pairs, shortly petioled, oval, oblong, entire, very obtuse or even emarginate and smooth.	Leaves 8–12 pairs, ovate and ovate-lanceolar or sub-lanceolate.
Stipules crescent-shaped, lower half narrower, less obtuse, upper half much broader and emarginate with a bristle.	Stipules obliquely crescent-shaped, extremities lengthened into long, subulate spurs, adnate.
Racemes terminal on short lateral branchlets.	Racemes lateral on the naked 2 or more year old branchlets, simple.
Petals oblong.	Petals lanceolate.

In their account of 'Some Beautiful Indian Trees', in the *Journ. Bombay Nat. Hist. Soc.*, Vol. 35, pp. 289–291, Blatter and Millard have figured and described these two Cassias. Their descriptions agree exactly with those of Roxburgh. They add there, that, like the Java Cassia (*C. javanica* L.), the flowers in *C. nodosa* 'come out in big distant clusters; . . . grouped along the branches in pairs or solitary and grow from the axils of the leaves or more usually above the scars of fallen leaves'. Their plate No. 13, which they have called *C. javanica* L. does not agree with their description of the species and it is certainly not the Linnean species, but is typical *C. nodosa* Ham. The attention of late Father Blatter was drawn to this when he was alive and he agreed with my identification of the plate as *C. nodosa* Ham.

The examination of a large number of specimens of these two species from trees which are in cultivation in and around Calcutta and of the herbarium materials coming from different parts of India has led me to conclude that by some inexplainable circumstance Roxburgh or his publisher has interchanged the description of one with the other. Probably Roxburgh's artists who drew for him the figures of *C. bacillus* Gaertn. and *C. nodosa* Ham. were responsible for this unfortunate mistake. Except for the unpublished Icone N. 1835 of Roxburgh's *C. nodosa* Ham. in the Sibpur library, there is perhaps no possibility of verifying the description of *C. nodosa* Ham. with his type as the latter is not available at Sibpur. Roxburgh cited Rumphius's plate No. 22 of *Herbarium Amboinense* under his *C. bacillus* Gaertn. but I consider that Rumphius's plate No. 22 is certainly not *C. javanica* L., but that it is only *C. marginata* Roxb. which can easily be made out by the ovate, subulate stipules and the axillary panicle of small flowers, with oblong, elliptic, acute, petals.

As accepted by all authors, the outstanding character of *C. javanica* L. is the oblong, obtuse leaflets. There are other well-marked characters also which distinguish the Java Cassia

from the rest of Cassias with flowers of the same colour. There are several plants of the typical *C. javanica* L. growing in Calcutta of which the best specimen is in the north-eastern end of the Zoological Garden, Alipore. There are also specimens of this plant in the Royal Botanical Garden, Sibpur, and in the Agri-Horticultural Gardens, Alipore. There was a beautiful specimen of this rare Cassia in the Curzon garden, Calcutta. But it had to be cut down probably on account of injury. This Cassia

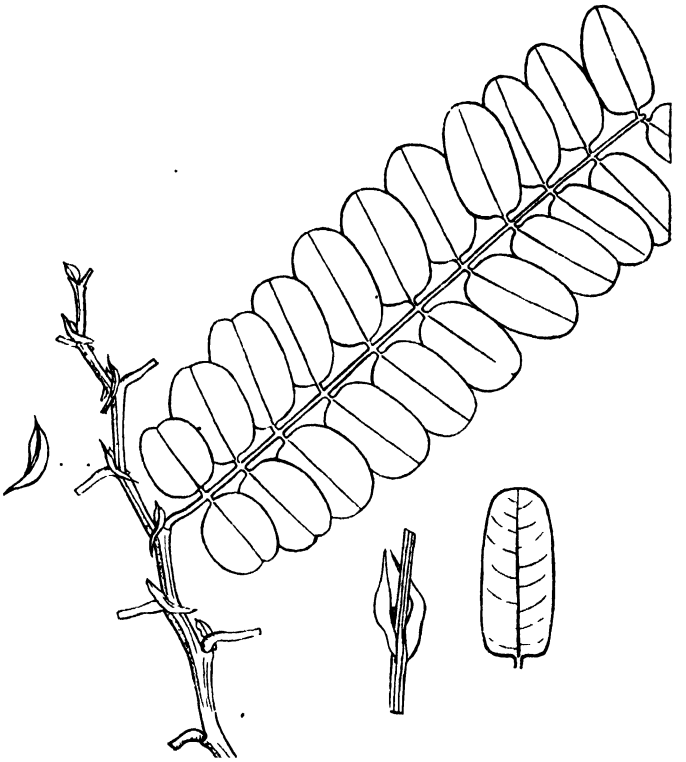


FIG. 1.— *Cassia javanica* Linn.

appears to be the rarer of the two Cassias under discussion and greater attempt should be made to spread this more extensively than has been the case hitherto. If proper attention is not paid, it may become extinct in no distant date.

C. JAVANICA L.

C. javanica L. is a medium sized tree about 30 ft. high and with a circumference of 1–5 ft. at the base, spiny on the

trunk below, with a flat or round spreading crown and with feathery-leaved long drooping branchlets. There are 9–14 pairs (usually fewer) of oblong, round, obtuse, often retuse and mucronate leaflets; opposite below and alternate above, veins distant and with narrow crescent-shaped stipules. The stipules, especially those at the tips of the young branchlets, have their ends produced into short subulate spurs or tails. This feature of the stipules is attributed by Roxburgh to *C. nodosa* Ham. but it is scarcely so in the specimens with oblong, obtuse leaflets which are typical of *C. javanica*. The flowering racemes are stout, long, simple or in pairs, arising chiefly from the axils of the scars of fallen leaves, rarely from the tips of lateral branchlets; petals broadly oblong, elliptic, obtuse, pink in colour, fading to white.

C. NODOSA HAM.

C. nodosa Ham. grows to a larger size than *C. javanica* L. It is thorny on the trunk below when young only, but unarmed when older. The crown is flat and spreading with long drooping branchlets. The leaflets are 9–14 pairs, more often more, bifarious, ovate, oblong or lanceolate, acute or acuminate, with truncate bases and close-set veins. Stipules are broad, foliaceous, crescent-shaped, the upper half broader with a distinct midrib ending in a short mucro and the lower half shorter, narrower and veinless. Even at the tips of the young branchlets, this feature of the stipule is very characteristic in this species. Roxburgh attributed this character to the Java Cassia, but examination of a number of trees in cultivation in and around Calcutta has not supported that view. The position of the inflorescence is also another point of distinction between the two species. The inflorescence is a corymbose panicle of deep pink flowers at the tips of lateral branchlets. It has not been observed to be a simple solitary stout raceme arising from leafless old branchlets as in *C. javanica*. The petals are deep pink in colour, narrow, ovate, acute or obovate with a short claw. The shape of the leaflets and the stipules is alone sufficient to distinguish *C. nodosa* Ham. from *C. javanica* L.

In *C. nodosa*, the leaflets are very variable, the lowermost leaflets in some of the leaves are sometimes oblong, obtuse and even retuse. These two species are known now only in cultivation and there are numerous varieties which have probably evolved out of these two species or from only one of them. Gagnepain without assigning any reason, has reduced *C. nodosa* Ham. to *C. javanica* L. in Flora Generale de l' Indo-China in 1913. Later authors have not accepted this view and have treated them as two separate species. As hybrid Cassias are now coming to light under horticultural and natural conditions, it is more than likely that *C. nodosa* Ham. is of the nature of a hybrid or a variety of *C. javanica* L. But without a knowledge

of the nature of the chromosome contents of the two species, it is impossible to fix the relationship between the two species. It is a problem open to cytologists of this group of Indian plants.

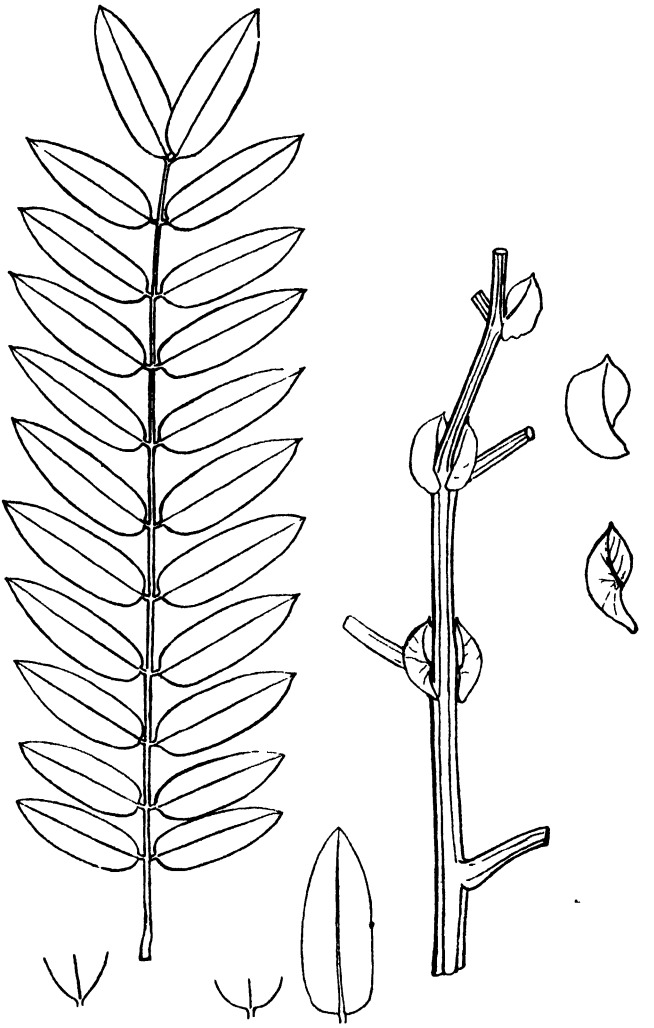


FIG. 2.—*Cassia nodosa* Ham.

OTHER TREE CASSIAS.

Besides these two species, there are other tree Cassias with beautiful flowers, in cultivation in the gardens and parks of

Calcutta. Of these, the Burmese pink Cassia, known as *Cassia renigera* is equally attractive in the profusion of its pink flowers, borne on drooping branches. But it is easily distinguished from the first two species by the peculiar kidney-shaped stipules and broadly ovate, subulate and auricled floral bracts. The next is what is called as Red Cassia—*C. marginata* Roxb., a smaller round-topped tree 15–20 ft. high and with slender downward curving branches. There are 10–20 pairs of small, oblong leaflets, oblique and acutely narrowed at the base, obtuse and emarginate at the tips with a distinct mucro in the middle. The flowers are smaller and some of the stamens have no swelling in the middle as is common to the three first Cassias. There is another tree Cassia with pink flowers known as Horse Cassia *C. grandis* L.f., a native of America, but which has come into cultivation in several gardens of India. This is distinguished from those with pink flowers chiefly by the compressed cylindrical pod, 'rough with transverse markings, one margin, with a prominent obtuse rib, the other with 2 prominent ribs'. The pod is 1–1·9 ft. long and not 3 inches or less as stated by Blatter. *Cassia fistula* L. is the common Indian laburnum with pendulous racemes of golden yellow flowers. Though it is similar in the nature of its cylindrical pods to the pink or red Cassias, it is easily distinguished from them by its fewer pairs of broad, ovate leaflets and yellow flowers which do not have the nodose swelling in some of the stamens. *Cassia siamea* is another of the avenue plants, common in Calcutta and is made out easily from the rest by the numerous thickly coriaceous, glabrous leaflets, its terminal panicle of small yellow flowers and its strap-shaped pods.

Cassia multijuga Rich. is a shrub with numerous pairs of small close-set oblong, obtuse, emarginate leaflets and a terminal panicle of small yellow flowers and a strap-shaped pod. An artificial key is appended for the easy recognition of the several species.

Artificial key to the cultivated Cassias.

A.	Pod smooth, cylindrical, long.	
AA.	Flowers yellow	*C. fistula* L. 1.
AAA.	Flowers pink or red—floral bracts narrow, ovate, subulate.	
	Leaflets small, oblong, oval, obtuse or emarginate at the tip, base equal, round, stipules semilunate with 2 subulate tails from the ends.	*C. javanica* L 2.
	Leaflets small, narrow, oblong from an oblique base, obtuse, emarginate with a median mucro.	*C. marginata* Roxb. 3.

	Leaflets bigger, oblong, ovate, acute, base equal, acute or somewhat round, stipules semilunate with the upper half broader and bigger.	*C. nodosa* Ham. 4.
AAAA.	Flowers pink, floral bracts broadly ovate, subulate, with two obtuse basal auricles, cauline bracts reniform.	*C. renigera* Wall. 5.
B.	Pod, cylindrical, rough, compressed; leaflets narrow, oblong, obtuse, round at both ends.	*C. grandis* L.f. 6.
C.	Pod, smooth, strap-shaped, flowers yellow.	
C′.	Leaflets, thick, coriaceous, glabrous, narrow, long, oblong, obtuse, emarginate and mucronate. Flowers yellow, stamens subequal.	*C. siamea* Lam. 7.
C″.	All stamens perfect. Pod 6–8″, flat.	*C. glauca* Lam 8.
C‴.	A shrub, leaflets many, small, oblong, obtuse, emarginate, mucronate, minutely puberulous on both sides.	*C. multijuga* Rich. 9.

Summary.

The correct identification of the two most beautiful of tree Cassias, namely: the Java Cassia, *Cassia javanica* L. and the Busuk-Busuk *C. nodosa* Ham., that are commonly met with in cultivation in several parts of India has for long been unsatisfactory. Of these, the Java Cassia is the oldest species, established by Linnaeus in 1753. Probably on account of long cultivation under artificial conditions, it has become very variable and it may not be unlikely that *C. nodosa* Ham., is one of such variations that has now become firmly established with clear-cut characters of a true species. Cytogenetic tests may perhaps solve this probability. Apart from this supposition regarding the origin of *C. nodosa* Ham., these two species differ from each other markedly so as to considerably minimize the chances of their being mistaken one for the other.

C. javanica is easily distinguished from *C. nodosa* by: (1) the semilunate stipules, produced at the two ends, into two subulate tails, (2) by the small, oblong, oval leaflets, equal and rounded at the base and rounded, obtuse or slightly emarginate at the tip, and (3) by the oblong, obtuse, petals rounded at both ends. In *C. nodosa*, on the other hand, the leaflets are oblong, ovate, acute apically and acute or somewhat rounded at the base; the stipules are semilunate with the upper half broader with a distinct median nerve ending in a mucro and the petals are long, narrow, oblong, acute at both ends.

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ARTICLE No. 5.

Blood Grouping in the Deccan and Eastern Ghats.

By EILEEN W. E. MACFARLANE.

In order to fill in some of the great blank space in the blood group survey map of India which stretches from east to west, right across the centre of the country (Sarkar) an extensive trip was undertaken into the Deccan and Eastern States Agency early in 1940.

Any field worker who has contacted our tribes and aboriginals knows that they usually occupy inaccessible areas and that it is frequently difficult to persuade them to co-operate in an unusual project. Most of them are independent minded, as well as suspicious and superstitious folk. Weird rumours may circulate about the motives of a person who attempts to collect drops of their blood. Should they be alarmed or offended in any way they stage a spontaneous boycott, even hostile demonstrations are still not unknown. Now that they are familiar with medical officers, who vaccinate and inoculate, a blood tester can pass as such and presents of sweets, nuts and glass bracelets overcome a lot of resistance. Even so some Banjaras refused to co-operate because blood had been taken first from the Bhils and many of the Chenchus simply stole away into the forest leaving the villages to us. The other workers in India will realize that it is often impossible to obtain the 200 samples from each community which the statisticians demand (Boyd) without a prolonged, uncomfortable and expensive sojourn. Even if one decides to stay on hopefully, there is no guarantee that those who refused at first will relent later. Distances are great and transportation slow and it is often impossible to replenish stocks of test sera without days of delay.

Although my samples fall short I hope to show that they are probably representative and that these data throw light on blood group distribution in south-eastern Central India.

METHODS ADAPTED TO FIELD CONDITIONS.

The technique followed was that previously used in the laboratory, i.e. open slides in petrie dish moist chambers (Macfarlane, 1939). Small sterile test-tubes with cotton plugs and containing 1 c.c. normal saline were prepared each morning.

These, in their stands, were carried into the jungle or village in a light wooden box, together with spirit lamp, swabs and presents for donors. Name, sex, approximate age, caste or tribe and birthplace are recorded for each person just before he is punctured and the number of the corresponding test-tube is noted in the ledger. Blood was taken from finger-tips, even though some were unbelievably dirty and gnarled, because the people prefer this. Speed is important, and once a crowd starts to dwindle, deserters are difficult to catch. For this reason the blood was collected directly into the test-tube. Malaria and poor diet cause a lot of anaemia among tribal people and it may be necessary to take three or four drops in some cases. In hospitals and prisons everything is simple. Prisoners in Hyderabad and Bastar States showed the benefit of a balanced, adequate diet and medical care in the quality of their blood. In the villages a flamed pin, which can be concealed between the fingers to administer a quick, painless puncture, when the donor's attention is diverted, is less alarming than a surgeon's needle. Each pin should be used only two or three times. Presents should be given after the blood is obtained.

When all available bloods had been taken the samples were carried back to the rest-house in the box. The supernatant fluid was poured off each deposit of red blood cells, before testing, and sufficient saline added to give about a 2% suspension, judged by the colour. Bloods were sometimes left in the test-tubes for four or five hours and transported for many miles without any deleterious effect. After five hours some haemolysis occurred in a few samples when the temperature was over 90°F. The samples were usually washed and tested in two or three hours after collection.

The test sera were checked each day with Group AB and Group O blood cells. Also a selection of samples was always retested as a further check. The opened ampoules of test sera were sealed with plasticine clay, if necessary, and kept on ice in a vacuum bottle.

Chenchus.

The Chenchus are a small forest tribe, still in the food hunting stage of culture, who have attained considerable fame in anthropology, thanks to the interest and activity of Mr. Gulam Ahmed Khan (1931), last Census Commissioner of the Nizam's Dominions. Dr. B. S. Guha and Dr. J. H. Hutton both visited this tribe in the company of Mr. Ahmed Khan in connection with the last census, at different times, and the former was able to measure twenty-three of them (Guha, 1933). I was fortunate enough to have the same guide.

The Chenchus inhabit a rocky plateau in Amrabad Taluk, north-east of the Kristna River, in Mahbubnagar District on the southern border of Hyderabad State.

A cholera epidemic a few years ago killed hundreds of these forest folk and it was the opinion of the Forest and Medical

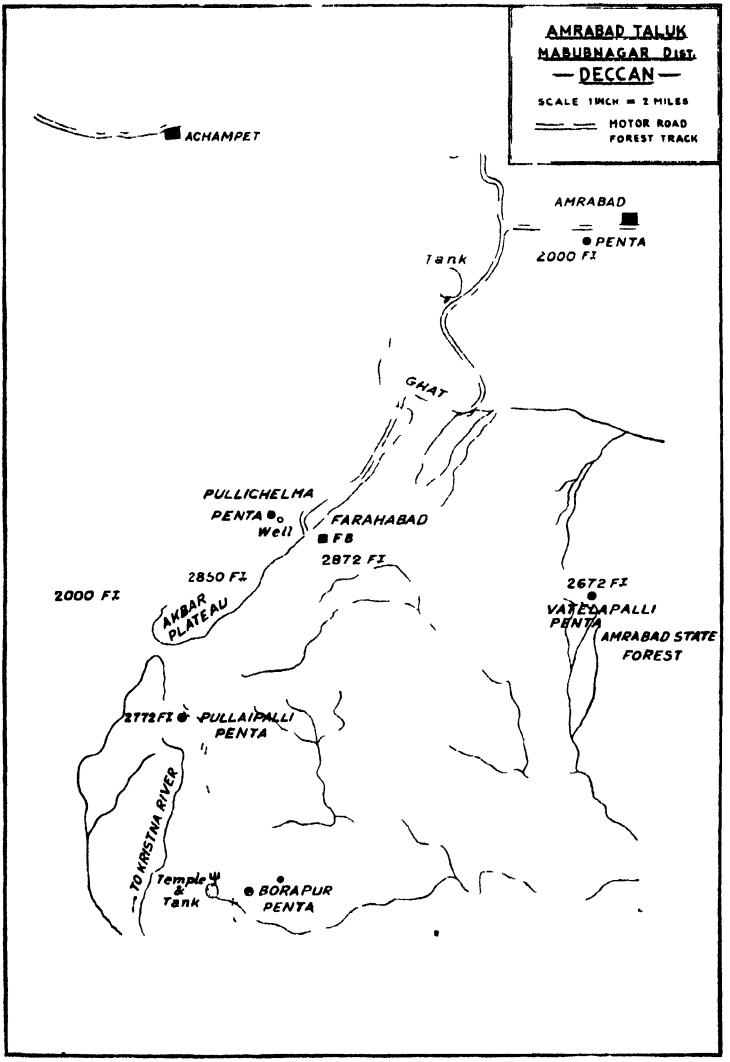


FIG. 1.—Map of five Chenchu Pentas visited in Amrabad Taluk. [F.B. = Forest Bungalow. From F.B. to Vatelapalli = 6 mls. From F.B. to Borapur = 12 mls. by forest track.]

Officers of the District that only 200–300 now remain in the area we visited. In the 1931 census 2,000 Chenchus were returned

living in 53 settlements. In the decade before that their numbers had decreased 63% from over 6,000 in 1921. Yaws has now appeared among them from the south and it is doubtful if they will survive another twenty years here. Dr. Baron C. von Fürer-Haimendorf was met in the interior where he was living in a Chenchu settlement with his wife and interpreter engaged in ethnological study. There is another branch of the tribe in the Madras Presidency, south of the Kristna River, in the Nallamalais range. These were visited some years ago by Dr. Baron von Eickstedt (1934) who reported that they were already mixed with 'Melanid' stock.

The Chenchus live in small groups of round basket-work huts with pointed thatched roofs. The settlement is called a *Penta*. Five *pentas* scattered over some 200 square miles of open forest were visited from the Farahabad Forest Bungalow (see map, text fig. 1). Each *penta* consists of eight or ten huts sheltering from 25 to 40 persons. Since blood is not desired from parents and their children in a general survey of a tribe, only about half the population of a village can sometimes be utilized. In small tribal groups like the Chenchus, where inbreeding is naturally pronounced, one child is sometimes tested, when offered, as well as the parents. In fact, everyone is related to everyone else.

A Government vaccinator had been in the area a week before our visit and some Chenchus (particularly those among whom the ethnologist was living) refused to undergo any more pricking. In fact in the interior nearly everyone went away into the jungle upon our approach and were seen no more that day. They are tired of being investigated. The Chenchu men spend every day hunting for food: seeds, fruit, roots and mice, and few can be contacted except early or late. They grub for roots with crude knives and their finger, so that the skin on the latter is more like bark.

A total of just one hundred bloods was obtained from these five settlements and over half of these were from Amrabad at the foot of the ghat where the Chenchus are becoming civilized. At Amrabad the men wear belts and tend herds, while the women work for wages—they were shelling castor beans with small wooden paddles when we went there. Everyone there volunteered to be punctured. In the interior after travelling miles through rough jungle during three days and waiting in the open in a settlement for hours only 46 could be enticed from four *pentas*. Nevertheless, the geographic distribution of the blood groups is interesting (Table I). In Amrabad 27 persons in 50 belonged to Group A and only 8 to Group B. On the plateau 17 out of 25 persons belonged to Group O from the three *pentas* of the interior: Borapur, Pullaipalli and Vatelapalli, and only 3 to Group B. Pullichelma *penta* is now called Farahabad because of its proximity to the Farahabad Forest

TABLE I.

Blood Groups of Chenchus by Pentas.

Penta	Nos. and percentage of persons in Group								Intermarry with	
	No.	O		A		B		AB		
1. Farahabad	20	7	35%	6	30%	6	30%	1	5%	1, 2 and 5
2. Vatelpalli	10	4		2		2		2		2, 1, 5. (rarely 3 and 4)
3. Borapur	8	7		0		1		0		3, 4 rarely 2.
4. Pullaipalli	8	7		1		0		0		4, 3 rarely 2.
1st 25 from 2, 3 and 4 (interior)	25	17	68%	3	12%	3	12%	2	8%	chiefly each other.
5. Amrabad	54	12	22%	28	52%	9	17%	5	9%	5, 2 and 1.
All *pentas*	100	37		37		18		8		

Bungalow. Its male inhabitants work for the Forest Department providing water and fuel. One-third of the inhabitants of Farahabad *penta* were found to be in Group B which seemed to indicate a mixed stock. The following information was obtained from Dr. Baron von Fürer-Haimendorf in a private communication 'As far as I know the Chenchus at Pullaipalli and Borapur do not intermarry with those near Amrabad, although they intermarry very occasionally with those of Vatelapalli. Those of Vatelapalli, on the other hand, do intermarry to a certain extent with those near Amrabad and also with the people of Farahabad. The latter are a mixed crowd and from them I have heard complaints about Forest Guards seducing their girls. So a high proportion of B is not astonishing here'. Mating habits and blood group distributions of the various *pentas* are shown in Table 1. The people near Amrabad and those of the interior would appear to be highly inbred, which is indicated by a preponderance of Groups A and O respectively. Group B seems to be percolating in through miscegenation and it is probable that the Chenchus in their pristine condition, until the area was opened up nearly forty years ago (Khan), belonged almost exclusively to Groups A and O like the Paniyans (Aiyappan) and other pre-Dravidians of the Western Ghats (Macfarlane, 1936). This is a characteristic of many aboriginal stocks throughout the world, but in the peninsula of India it has only been found among the tribes of the southern Western Ghats. The very high percentage of Group A among the Paniyans of Wynaad is probably also the result of inbreeding among the descendants of a few original families. Sarkar has recorded the preponderance of one blood group in one village and of another in others among the Hill Mālér and credits this

distribution to local inbreeding. In his racial distribution map von Eickstedt grouped the Chenchus with the tribes of the southern Western Ghats. The frequencies of the agglutinogen genes also point to some peoples of the Malabar region as most similar to the Chenchus.

The serological value A-B in the Chenchus is +19. The only other communities thus far discovered in India with a preponderance of Group A over Group B are the Paniyans (+52·8), Mixed pre-Dravidians (21), Illuvas (12) and Nairs (13) of Cochin, Malabar Coast.

Guha (1935) found that the coefficient of racial likeness pointed to the Bhils of the Vindhya Hills as the closest relatives of the Chenchus. (Plate 2, Figs. 1 and 2)

Bhils.

There are no blood group data from the Bhils measured by Dr. Guha[1]. He reported that some of the communities appeared to be of mixed stock. While in Hyderabad State I visited Kannad Taluk in Aurangabad District in the extreme north-west. Through the good offices of Mr. G. Ahmed Khan and the local revenue officials some Bhils of both sexes were brought into Kannad. Some of them are descended from converts to Islam and now call themselves 'Muslim Bhils'. They intermarry among their own small group. These Bhils are primitive agriculturalists and all appeared to be strong and well built. Only 44 bloods (Table IV) were obtained and 11 of these were from Muslim Bhils. Of the latter 8 were B and the rest Group A, which is indicative of their inbred condition, even in this small lot. In 33 Hindu Bhils the distribution was: Group O 14, Group A 3, Group B 15, Group AB 1. (Pl. 2, Figs. 3 and 4). It seems that these Bhils possess a lot of Groups O and B and perhaps little of Group A. The Pods of Bengal are the only community previously reported to have this type of distribution (Sarkar). The three groups are more or less evenly distributed among the Santals and other aboriginal tribes of eastern India.

As an indication of what we may expect these Bhil data have been included in Table IV. More data are urgently needed from this important tribe. I shall be glad to send mine, with all particulars to anyone who has other blood group data from Bhils.

It may be that in the Bhils we have one of the reservoirs of Group B in India from which it has percolated to higher social castes, for the Bhils have an ancient tradition as soldiers and

[1] The results of blood grouping among the Bhils in the Central Provinces by Dr. Gorlitzer working with Rev. Dr. W. Koppers have not yet been published (*Man in India*, 1940: 20: pp. 178–181).

artisans. There were 15,000 Bhils in the hilly parts of north-west Hyderabad State at the last census and the tribe was increasing.

Depressed Classes of the Deccan.

The Depressed Classes, sometimes called *Adi-Hindus* or Untouchables, are found everywhere in the plains of India. They are probably the descendants of some aboriginal pre-Dravidian stocks (Dutt). They have been segregated socially to do the meanest types of labour for millenia.

There are always some days on a tour when one is forced 'to halt' and the main object cannot be pursued. When this happened in Hyderabad city and in Aurangabad (350 miles to the north-west) I utilized the time in grouping bloods from the Depressed Classes at dispensaries, hospitals and jails. There is

Table II

Blood Groups of Depressed Classes, Deccan, by Region and Caste.

Sample from	Nos. and percentages in Groups				
	No.	O	A	B	AB
Aurangabad Dist.	22	4	5	12	1
Southern half of H. State	50	17 *34%*	9 *18%*	21 *42%*	3 *6%*
Dhars, Mahars and Mangas	50	17 *34%*	8 *16%*	21 *42%*	4 *8%*
All Dist Hyderabad State	75	24 *32%*	14 *18·7%*	33 *44%*	4 *5·3%*

no difficulty in obtaining them, but they are everywhere regarded as of no interest. Test sera had to be husbanded and I only took bloods from 75 *Adi-Hindus*. These came from all over the State and from several castes, yet the blood group proportions seem to be very similar however the samples are grouped, even by fifties as shown in Table II. The castes represented were: Dher (26), Mahar (16), Mang (5), Dhobi (6), Meta (4), Mala (4), Bhoi (3), Chambhar (2) and a few others contributed one. It is doubtful whether there is any ethnological or genetical difference between most of these and many other of the lowest occupational castes. When tribal life disintegrates many such castes crystallize out as they are now doing from the Marias and Murias of Bastar State (Majumdar).

The blood group proportions among these people in the Deccan are strikingly similar to those of the Depressed Classes of Bengal south of Calcutta, including the Mahishyas, and so are the frequencies of the three genes (see Table IV and Macfarlane, 1938). Dr. Guha's opinion that the basic social stratum

is a fairly homogeneous one over most of India is given support by these data. It is over a thousand miles from Calcutta to Hyderabad, Deccan.

If some Mongolian tribes of Central Asia with a high percentage of Group B are excluded, then the only communities in the extensive list recently published by Boyd in which over 40% of Group B and a frequency for gene B (q) of over 0·300 have been reported are: some of the Gypsies of Hungary and Yugoslavia, some Sundanese of Indonesia, the Moros of Siasi, Philippine Islands, some Ainu of Japan. The Brahmans in one part of the Island of Bali show 42·6% Group B, $q = ·288$, in other parts there is less B The Gypsies are generally believed to have originated in India and some of the others in this list may well have ancient affiliations with this country If agglutinogen B has spread through the world largely from India as some believe (Bijlmer), then one of the chief sources here seems to have been the ancestors of the present Depressed Classes.

Banjaras.

At Aurangabad and Hyderabad city a few bloods were also taken from the picturesque Banjaras The caste is also known as Lambara here (Khan) These were originally a wandering tribe who carried goods by pack animals. The railways have almost ruined this business and many of them are now settling down as cultivators, others still are peddlers The women's costume is very elaborate, they are weighted down with heavy ornaments and as they tramp the dusty roads they might well be refugee princesses (Pl 2, Figs 5 and 6) They are a proud race of hysterical temperament and not easy to approach.

These few data do not resemble so much those from the Gypsies of Europe, whom the Banjaras call to mind, as the Indo-Aryans (Jats and Khatris) of Kashmir and the Punjab. One of them told us that they were related to the Mahwaris. Eickstedt somewhat sweepingly asserted that they are 'extremely hybrid and contain Gondid elements, though of course alongside Indid and Orientalid strains'.

These figures are given (Table IV) in the hope that others may be obtained from this romantic tribe.

Maria Gonds of Bastar.

Jagdalpur the capital of Bastar State was visited next. Here helpful co-operation was extended by the Administrator, Mr. E. S. Hyde, I.C.S., and the Government medical officers.

Transportation was a difficulty and those whom were consulted thought that I might have trouble in the villages. Upon the advice of Mr. W. V. Grigson, I.C.S., I decided to concentrate on the Bison Head Marias also called Dandami

Marias (Grigson). These people are hot tempered and have pronounced homicidal tendencies, hence numbers of them are to be found in the Central Jail, Jagdalpur, serving long sentences for murder, attempted murder, culpable homicide and for causing grievous hurt (Pl. 3, Figs. 1–5). There is also a Yaws clinic in connection with the Maharani's hospital, Jagdalpur, to which many Marias come before the rains. Patients stay for some time and are accompanied by numerous healthy relatives, all of whom are fed free by the Government. I was permitted to take blood samples from prisoners in the jail and from healthy Marias camping at the Yaws clinic (Pl. 3, Fig. 6). Bloods were also taken from a few Bison Head Marias who had come in on their way to work in the tea gardens. I could probably have obtained a total of 200 Maria bloods in another week or ten days if my supply of test sera had not been cut short by accident.

TABLE III.

Blood Groups of B. H. Marias by Region and Crime.

Sample from	Nos. and percentages in Groups				
	No.	O	A	B	AB
Dantewara Tahsil	50	16 *32%*	11 *22%*	18 *36%*	5 *10%*
Jagdalpur and Sukma Murderers, Whole State	50	13 *26%*	14 *28%*	18 *36%*	5 *10%*
All Bastar State	123	35 *28·5%*	32 *26%*	32 *34·1%*	14 *11·4%*

A total of 133 Maria bloods was obtained in Jagdalpur. When the names were shown to Mr. Hyde, he advised me that ten prisoners from Antagarh Tahsil in the north, and from Kondagoan Tahsil were not Bison Head Marias. They gave Maria as their caste but had only one name instead of the binomials found among the Bison Head people from further south. These ten may have been Jhoria Murias who are believed to be Hill Marias who have come to the plain (Grigson) and who chose to affiliate themselves with the large Maria group in the jail. Some of the tea garden recruits called themselves Maria-Murias, which merely indicates that they were Marias who claimed social advancement (Grigson). Among these ten Marias from the north-east there were: Group O 4, Group A 4, Group B 2. These data with details will be gladly sent to anyone who collects more from that area. The data from the other 123 Marias have therefore been kept separate (Table III). These latter came from Dantewara District (65), Jagdalpur District

(35), Sukma Zemindari (15), Konta District (5) and Bijapur District (3). Table III shows the percentage of blood groups in some selected samples of 50 or more Bison Head Marias. This tribe seems to be fairly homogeneous for them. All samples are characterized by roughly equal proportions of Groups O, A and B, with a regular small preponderance of B over A.

A similar distribution of the blood groups was found among the Santals of Santal Pergs. (Sarkar) and also among the Mahrattas of Goa (Correia). There are indications therefore that in a wide area across Central India, north of the Deccan, the aboriginal tribes possess all three blood groups in about equal amounts. If the frequencies of the genes (p, q and r) are compared, the Santals have a lower value for p than either the Marias or the Mahrattas.

TABLE IV.

Percentages of Blood Groups and Frequencies of Genes involved.

People	Place	No.	O	A	B	AB	p	q	r	D/σ
Maria Gonds	Bastar State	123	28·5	26	34·1	11·4	·215	·258	·533	0·3
Chenchus	Mahbubnagar Dist., Dc.	100	37	37	18	8	·252	·133	·608	0·4
Bhils B. H.	Kannad Dist. Deccan ..	44	31·8	13·6	52·3	2·3	·109	·353	·564	0·9
Banjaras	Hyderabad State ..	43	39·5	21	34·9	4·6	·149	·234	·628	0·4
Depressed Classes	Hyderabad State ..	75	32	18·7	44	5·3	·137	·297	·566	0·02

ACKNOWLEDGMENTS.

This investigation was made possible through a grant-in-aid from the Royal Society, London, and through the generous co-operation of H.E.H. the Nizam's Government and the Government of Bastar State who provided valuable facilities. I am also indebted to Mr. G. Ahmed Khan who ably managed my tour in Hyderabad State and to Mr. E. S. Hyde, I.C.S., for help and advice in Bastar State, as well as to the other officials of districts, forests, jails and hospitals who aided in various ways.

SUMMARY.

1. Blood group data were obtained from the following communities in the Deccan: Banjaras (Lambaras) 43, Bhils 44, Chenchus 100, Depressed Classes 75. In Bastar State bloods from 123 Bison Head Marias and from 10 other Marias were tested.

2. The Banjaras showed a Northern Indian blood group distribution.

3. Bhils near Aurangabad had a very high proportion of Group B (over 50%), perhaps due to inbreeding. They may be one of the reservoirs from which agglutinogen B has spread into the Hindu castes.

4. The Chenchus almost all belonged to Groups O and A, except at the place where miscegenation is known to have begun a few years ago. In this they resemble the Hill Tribes of the Western Ghats and the Malayali lower castes, with whom they share the distinction of being the only Indian Tribes to have more of A than of B.

5. The Depressed Classes of the Deccan showed 44% of Group B and frequencies of the three genes similar to that of the Depressed Classes in Bengal.

6. Bison Head Marias possess more or less equal proportions of the three main blood groups with a constant preponderance of Group B.

7. The larger conclusions that should be tested out with bigger samples are: (*a*) the apparent homogeneity of blood group mixture in the Depressed Classes right across the Deccan and into Bengal, (*b*) the probable similarity in the blood group proportions among aborigines of Gondwana Land, Behar and Central India across to the northern Western Ghats.

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Explanation to Plate 2.

Fig. 1.—Chenchu woman. Australoid type. Farahabad, Deccan.
„ 2. –Chenchu man. Australoid type. Picture appeared in 1931 Census, Vol. 23, as a boy.
„ 3.—Bhil man. Kannad, Deccan.
„ 4.—Profile of 3.
„ 5.—Banjara man. Kannad, Deccan. Ancient Bhil in background.
„ 6.—Banjara women. Aurangabad, Deccan.



FIG. 1. Chenchu woman



FIG. 3 Bhil man



FIG 5 Banjara man



FIG. 2. Chenchu man



FIG. 4. Profile of fig. 3.



FIG 6 Banjara women.

Explanation to Plate 3.

Fig. 1.– Bison Head Maria, murderer, Jagdalpur. Negroid type, hair not kinky, shaved.

,, 2.—Profile of 1.

,, 3.– Bison Head Maria, murderer, Jagdalpur. Palaeo-Mongoloid type?

,, 4.—Profile of 3.

,, 5. Bison Head Maria, murderer awaiting trial, Jagdalpur. Gond type. Unusually strong development of facial hair.

,, 6.—Bison Head Maria girl. Australoid type.

FIG. 1 Bison Head Maria

FIG. 2 Profile of fig 1

FIG. 3 Bison Head Maria Gond

FIG. 4 Profile of fig 3

FIG. 5 Bison Head Maria

FIG. 6 Bison Head Maria girl

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ARTICLE No. 6.

The Magic Cakras [1] and Rectilinear Orbits in Ancient Astronomy.

By C. P. S. MENON.

(*Communicated by Prof. M. N. Saha.*)

1. Ever since Aristotle laid it down as an indisputable truth that the circle, having neither beginning nor end was the most perfect figure and, as such, the most fitted by Providence to represent the eternal shapes of the Universe and, in particular, of the celestial orbits, we have been accustomed to astronomical theories attributing to the celestial orbits a circular shape or else a shape closely dependent on the circle [2], so much so that it looks strange if we were told that at one time there were schools of thought which attributed rectilinear motion to the celestial bodies. We do not even take due notice of the fact that Aristotle and others were refuting such doctrines while asserting the perfection of the circle and its consequent choice by the *Primum Mobile* as the appropriate form for moulding the celestial orbits. Either because these strange beliefs could not stand the searchlight of criticism, or because of their inherent appeal to latent *reality* as distinguished from *appearance*, or more probably due to both these causes, they no longer appear in the fold of the rational sciences, but they seem to have survived in the more favourable atmosphere of astrology and the occultistic and mystic codes. Hence it is but proper to ransack these codes to collect bits of evidence which are likely to throw some light on the old system of belief in rectilinear motion.

A good deal of evidence of the belief as well as of its connection with a square-shaped Universe, with magic *Cakras* and with art and architecture of the ancients has been set forth by the present writer elsewhere [3]. The purpose of the present paper is to shed more light on those beliefs and to indicate a closer connection between the magic *Cakras* and the rectilinear

[1] 'C' pronounced as 'ch' in 'chair'.

[2] Thus the later Greek theories of Eccentrics and Epicycles are still dependent on the circle; while Kepler's ellipse may be broadly regarded as a modification of the circle.

[3] *Early Astronomy and Cosmology* (London, 1932—History of Science Library edited by Prof. A. Wolf.) The book also contains plenty of references to other features common to the Hindu, Chinese, Babylonians and other ancient civilizations, such as the *Nakshatras* and the *Sieou* and other divisions of the Zodiac, and their relation to the Square Scheme. See Index *s.v.* Borders, Creatures, Decans, Lunar Mansions, Zodiac (divisions of).

orbits; an attempt is also made to furnish a plausible explanation of these *Cakras* as also of their beliefs in rectilinear motion itself.

2. Before proceeding to deal with these entirely new pieces of information, it is desirable to gather here, in brief, a few of the more important points described in the above book in support of the theory, and a few similar points.

Several of the old Ionian and some Greek philosophers held that the *phenomena* were different from *reality* and they had theories of the latter by means of which they sought to explain the former[1]. Xenophanes of Kolophon (born about 570 B.C.) seems to have taught that the motion of the celestial bodies is rectilinear, the apparent circular forms of their daily orbits being only an illusion caused by their great distance from the observer[2].

Similar references to real orbits as distinct from apparent ones are met with in the *Sūryaprajñapti*, a Jaina astronomical treatise, and in a Chinese work called the *Tcheou-pei*[3]. These

[1] To quote a few instances:—Anaximander of Miletus (Circa 6th cent. B.C.) held that the sun, moon and stars were each a wheel of fire with a number of holes in the rim, through one or other of which the fire was visible at a given time, the other holes being closed; the eclipses occurring when the vents were all shut up. He arrived at this conclusion by starting from the premise that the first principle (material cause) was the Infinite and arguing that from this was separated 'that which is capable of begetting the hot and the cold', from which arose, in virtue of eternal motion, 'a sort of sphere of flame', and whence in turn were torn off the rings of fire mentioned above. Other philosophers followed in the same way arguing from the premise of a primordial substance and arriving at various conclusions about the shapes of the heavens and the heavenly bodies and their appearances and disappearances (*cf.* Doxography). Parmenides of Elea (early part of 5th cent. B.C.) maintained that the apparent rotation of the heavens is an illusion, since there is no such thing as *void*, and change and motion cannot be conceived without an empty space; and further that attainment of truth about the phenomenal world was impossible because of the imperfection of our senses (*op. cit*). Again, regarding the Pythagorean belief in the motion of the earth and a 'counter-earth' round a central fire, Aristotle remarks '....in this they are not seeking explanations and causes to fit the observed phenomena, but they are rather straining the phenomena in the effort to make them agree with certain explanations and views of their own. Many others might agree with them that the place in the centre should not be assigned to the earth, if they looked for confirmation, not to the observed facts, but to *a priori* arguments' (De Caelo, B 13, 293, A 15-b 30);—*e.g.* (1) Fire is worthier than earth to occupy the worthiest place, the centre of the heavenly sphere (*loc. cit.*) and (2) 'regarding as they do the number ten as perfect and as embracing the whole nature of numbers, they say that the bodies moving in the heavens are also ten in number, and, as those which we see are only nine, they make the counter-earth the tenth' (Metaphysics A 5, 986a 1).

[2] *Cf.* Aetius II, 24. He also held that 'there are many suns and moons according to the regions, divisions and zones of the earth'—*cf.* the double set of constellations, sun and moon mentioned in the *Sūrya prajñapti* and the *Tcheou-pei* (see below).

[3] *Cf.* Thibaut's article on the *Sūryaprajñapti*—J.A.S.B. Vol. 49, p. 203 *seq.*; Menon: *Op. cit.*, pp. 28, 91 *seq.*, 162, 167; also *infra*, footnote 2, p. 53

explain the rising and setting of the stars by their becoming visible at certain distances from us [1]. Also, the change of altitude of the mid-day sun throughout the year is explained by giving them a series of daily orbits on a horizontal plane above which become wider from summer solstice to winter solstice and shorter on the backward journey from winter solstice to summer solstice. Though the commentator of the *Sūryaprajñapti* proceeds to give the diameters and circumferences of these orbits, in a later chapter the text assigns a *square* orbit to the sun; the moon's orbit is yet held to be circular. There is little doubt that this work, and certainly the commentary on it, is a later exposition [2] of a very early cosmology founded on the square scheme many of whose features are mixed up with later ideas corresponding to a circular or spherical cosmology; this is presumably the reason for assigning the square shape to the orbit of one body and the circular shape to another. The Buddhistic times especially seem to be involved in the transition from the square to the circle. For, a similar transition is found in the shape of Mount *Meru*, the centre

[1] Anaximenes of Miletus held that 'the sun is hidden from sight, not because it goes under the earth, but because it is concealed by the higher parts of the earth, and because the distan e from us becomes greater' (Hippolytus Refut. I. 7).

[2] The *Sūrya-prajñapti*, judged by the general astronomical features of its contents such as the five-year cycle, belongs to the post-vedic and pre-Siddhāntic period of Hindu Astronomy to which also belong the *Jyotisha-Vedānga*, the *Mahābhārata*, some of the Purāṇas, the fragments of Vṛiddha-Garga, etc.; this period according to P. C. Sen Gupta is 1400 B.C.—2 A.D. (*cf.* The Cultural Heritage of India—Ramakrishna Centenary Memorial, Vol. III, p. 347); or to be more conservative, I put it between the 12th cent. B.C. and the 1st cent. A.D.—the upper date being determined by the position of the solstitial colure mentioned in the *Jyotisha-Vedānga* and other texts (allowing for possible errors), and the lower date by the mention of 2 Śāka (80 A.D.) in the *Paitāmaha Siddhānta* of Varāhamihira's *Pancha-siddhāntika*. Some features like the double set of constellations and quadrangular Meru (*vide infra*) are attributed to *Jina* himself: 'भाणि चतुःपञ्चाशत् द्वावर्कोदयौ जिनोक्तं यत्' (Bhāskara: *Siddhānta Siromani*). According to Jaina tradition represented by a current era, Mahāvīra was born about 599 B.C. (*cf.* Cultural Heritage of India, Vol. I, p. 220); and Gautama Buddha, the junior contemporary, passed away about 485 B.C. Hence I consider that most of the characteristics of the text must have been formed and gathered together by about 500 B.C. It is quite possible, and even probable, that the Māgadhi text itself was composed or systematized in the present form as one of the Jaina secondary canons only in the 1st cent. A.D.; the sanskrit commentary by Malayagiri is much later indeed. The astronomical features of the text are certainly very remote from those of the later and more scientific Siddhāntas of the period beginning with Āryabhaṭṭa (499 A.D.).

Tcheou-pei is one of the oldest Chinese mathematical texts, written at least as early as 1100 B.C., though some of the portions dealing with cosmology are regarded as later (2nd cent. B.C.); in the latter case, the scheme may have been imported by Buddhist missionaries from India (Menon: *op. cit.*, p. 92; Thibaut—J.A.S.B. Vol. 49).

of celestial motion in the above system: while its cross-section was regarded as 'quadrangular, not round' in 'the book of *Jina* i.e. of the Buddha,'[1] the Buddhists are reputed to have believed that Meru 'is square at the base, round at the top'.[2] The same transition from the square to the circle must have been the reason for the confusion in the minds of the priests of the *Brāhmaṇa* period, whether altars to be constructed for certain ceremonies should be in the shape of a square or a circle.[3]

The dimensions of the daily orbits of the sun and the height of the plane on which they lie, as seen from the 'extremity of the earth' (*Jambudvīpa*), which are detailed in the *Sūrya-prajñapti* appeared to be no more than absurd fancies of theologists. Indeed, they led to absurd results, when the orbits were taken as circular. For instance, since the distance between the two solstitial orbits must subtend at the observer an angle equal to twice the obliquity of the ecliptic ($= 2\omega$), the position of the observer is given by the intersection of a segment of a circle standing on a chord = 510 yojanas and containing an angle 2ω with a line drawn parallel to the chord at a distance of 800 yojanas. But actual drawing shows that the line does not meet the circle at all—tending to show that the figures were fictitious. On the other hand, assuming the orbits to be squares and the solstices to be represented by the corners[4], one could show that the given dimensions not only yield a possible value of the latitude (= 6°18′), but also an appreciably correct value of the obliquity. 6°18′ is obviously an appropriate value for the latitude of the end of *Jambudvīpa*, the southernmost point of Ceylon (Dundra Head) being now at a lat. of 5°56′N. This treatment gave sense also to another set of measurements described as observed from 'us'; the latitude of this 'our' place was obtained as 29°39′, which roughly corresponds to *Hastinapura* of *Mahābhārata* fame, where flourished a great civilization and great astronomers like *Vṛiddha-Garga* and *Parāśara*. Astronomers from this place evidently observed the changes of altitude of the sun here, and also proceeded to Ceylon to make further measurements, so as to deduce the dimensions of the orbits. Having calculated the distance between the solstitial orbits assumed to lie on a horizontal plane 800 yojanas above the end of *Jambudvīpa*, and then with the idea that the solstices correspond to the corners of the squares, reducing the distance to a difference between the *sides* of the orbits and of *Jambudvīpa* (also conceived as a square),

[1] *Cf.* Al Biruni's *India*, page 243; several *purāṇas* also make *Meru* square. *Cf.* Menon, *op. cit.*, p. 87 *et seq.*

[2] *Cf.* Al Biruni, *op. cit.*

[3] Menon, *op. cit.*, p. 74; there are several passages in the *Brāhmaṇas* to this effect.

[4] These assumptions are warranted by a large mass of evidence; *cf.* Menon, *op. cit.* Index *s. v.* Corners (sanctity of).

and further assuming a round number 100,000 yojanas for the side of *Jambudvīpa*, they seem to have arrived at the numbers given in the text. Thus what appeared to be absurd on the hypothesis of circular orbits is at once seen to be perfectly sensible and to yield remarkably accurate and appropriate results on the hypothesis of square orbits.

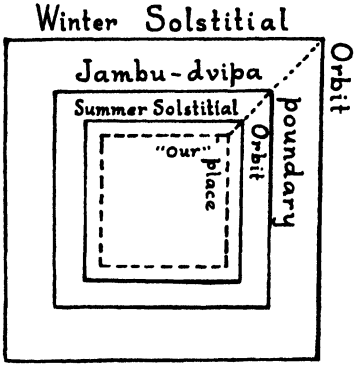


Fig. 1

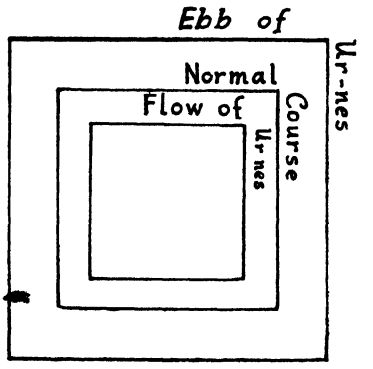


Fig. 2

(Ab = 180 yoj. bc = 330 yoj.
Ad = 40. Ac = $510\sqrt{2}$ yoj.)

3. A similar set of orbits (see Fig. 2) seems to be implied in the descriptions of certain cosmological conceptions of ancient Egypt. The Universe was a sort of rectangular box supported by four pillars at the cardinal points, which were connected by a chain of mountains. On a ledge somewhat below the top of these the celestial river *Ur-nes* flowed round the earth, carrying the bark of the Sun. During the course of the year, the *Ur-nes* ebbs and flows, the Sun's boat always keeping to the bank nearest to man; at summer solstice the river (like the Nile) overflows, so that the Sun's orbit is nearest to man and his altitude highest; whilst at winter-solstice the river ebbs causing the boat's path to be farthest from man and making the Sun's altitude least. There are also references to the *Ur-nes* turning *sharply* round at the southern point. The similarity of Fig. 2 to Fig. 1 is evident.

4. Apart from these daily orbits, the annual motion was represented by means of divisions of a square enclosure, and it is very probable that the zodiac itself was conceived as a square rather than a circular enclosure. In India one is familiar with the *Rāśi Cakra*, the square with its twelve small squares round the edges, which is used by the astrologer to represent the positions of the celestial bodies at any given time. The solstices and equinoxes were intimately connected with the corners of the square, as though the zodiac was actually conceived as a

square. There were other enclosures, like the horizon, which were also conceived as square (*caturanthā*) [1]. The Babylonian symbol for 'enclosure' is traceable to the primitive *Hal* symbol □, which is just a square [2]; the ecliptic was called *kes-da*, 'the enclosure' [3]. Several of these rectangular enclosures are found on Babylonian boundary stones, cylinders and seals in conjunction with animals of the early zodiac or other objects of definitely astronomical import.[4] The Chinese symbol for the earth was ⊞, a quadripartition of the square [5]. The Babylonian *Hal* symbol was also applied to *Zikum*, heaven; and again to *Apsu*, the Great Deep, wherein was rooted the world-tree which spread its branches into *Zikum*. Thus the rectilinear orbit appears as part of a square-based earth and a square-based Universe; and much of ancient symbolism and culture was bound up with the square form.

5. '*Astrological conceptions.*' The following extracts from an article in the *Encyclopædia of Religion and Ethics* [6] are worth quoting as further evidence confirming the theory of the ancient conceptions of rectilinear orbits and Universe and their symbolism and practical manifestations. After referring to the division of the zodiac and to the corresponding division of the observer's celestial equator 'into 12 apparently stationary parts', and showing how these parts called 'houses' [7] are connected with the horizontal directions, the writer says:

'This method of parcelling out the sun's apparent daily course must have been instituted at a very remote period, *in an age indeed when the astronomer had not yet grasped the idea of a circular orbit, but still thought of the solar path as a square.*[8] In the figure representing the horoscope [9] this quadrate form was retained, and it has remained in use till modern times, and in fact till the present day. To this method of delineating the stellar paths we shall frequently have to return, as a considerable number of symbols relating to God and the world were evolved therefrom.'

'The astrological conception of the world' is defended thus: '..... It is impossible to understand the theories of nature held by the ancients without a clear conception of the

[1] *Cf.* Monier Williams' *Sanskrit Dictionary.*
[2] *Babylonian and Oriental Record*, Vol. II, p. 258.
[3] Brown: *Primitive Constellations*, Vol. II, ch. XI.
[4] Menon, *op. cit.*, pp. 121–125.
[5] *Cf.* D'Alviella; *Migration of Symbols.*
[6] Vol. 12, pp. 54–56—article on 'Sun, Moon and Stars' by F. von Oefele.
[7] *Cf.* Menon, *op. cit.* Index *s. v.* Houses.
[8] Italics ours.
[9] See Fig. 3. The original square houses must have given place to triangles later; *cf.* Menon, *op. cit.*, pp. 73, 140.

difference between their fundamental stand-point and our own. According to the older view of the world which can be traced

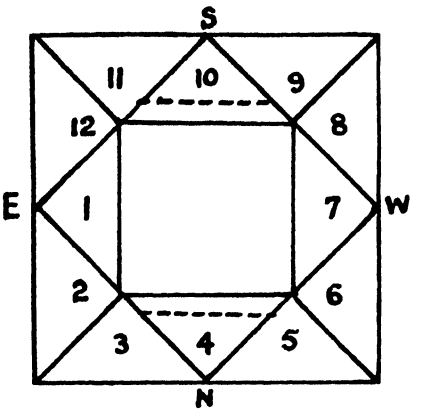


Fig. 3.

backwards for 5000 years before Christ, all natural objects issued in parallel lines from certain primary causes of universal operation. Modern Science, on the other hand, assumes that the various groups of physical phenomena proceed by differentiation from certain primordial forms'

He again refers to 'the square form of the horoscope, as furnishing the ground-plan' of this theory of the world, and as showing the link which the theory had with astrology and also with two other occult sciences, Alchemy and the Kabbala. He points out 'that the symbols used in astrology for the four cardinal points were simply the triangles corresponding to the first, fourth, seventh and tenth houses respectively [1] △ came to mean north, ▽ south, ▷ east and ◁ west.'

'The tenth house, as the *summum coelum*, and the fourth, as the *immum coelum*, embraced everything in the world above and the world below respectively. The upper world as a whole, however, consists of the eighth, ninth, tenth, eleventh and twelfth houses. In the hieroglyph script of Egypt, accordingly, heaven is represented by the exterior boundary of the five houses, thus :  . . . The underworld was represented of course by the same figure inverted According to one

[1] These symbols are just opposite to the plan given above; the incongruity is treated by the writer as due to the determination of the stars of the ecliptic by an observer in the north and the fixing of the cardinal points by his fellow in the south! But they agree with the orientation of the world described in our book.

conception, the *summum coelum* contains the heavenly upper ocean [1], from which rain falls, while the *immum coelum* contains both the ocean of the underworld and the sub-terranean waters from which the fountains of the deep [2] are fed. According to the other conception there lies above us first of all air, then fire; and beneath us, first earth, then water.'

The later theory furnished the alchemists' symbols of the elements: △ Fire,  Air,  Earth and ▽ Water. These symbols were used commonly by old physicians a hundred years ago; and sometimes in combination, e.g.  denoted 'burnt water' or distilled alcoholic liquors. The last symbol 'was used not only in alchemy but also in the Kabbala, where it represented a star of David. It became, in fact, a symbol for God' (Heaven being regarded as a synthesis of Fire and Water).

According to the astrological conception of the world, 'not only the perpendicular section through the universe, but the surface of the earth itself was thought of as a quadrate, since the cube, as the ideal geometrical figure, was the accepted symbol of the world as a whole. This idea finds frequent expression even in later cabalistic writings treating of the origin of salt, which, of course, also crystallizes in cubes. The scheme of the horoscope accordingly became a comprehensive map of the world as well'.

6. *A mural picture of the Universe.* In a picture on a templewall [3] depicting the *Brahmāṇḍa*, the cosmic-egg, the Sun is shown at the centre, *the orbits of Mercury and Venus are shown as a pentagram (five-pointed star) and a (convex) pentagon respectively* and Earth is in the ecliptic. Though this picture was painted at a comparatively recent date, there are several features in the scheme typical of the *Siddhāntas* and a few characteristic of the *Purāṇas* and the early rectilinear cosmology. It is presumably a mixture of several conceptions, ancient and later. The following is a translation of the relevant parts of the description accompanying the chart:

'At the centre of the Universe (Aṇḍa-kaṭāha) is the Sun. Nearest this Light of the World-theatre, the Sun, circumambulates Mercury five-cornerdly; beyond this Venus also in a pentagon; and still beyond this the earth revolves like a ball.

[1] *Cf.* Biblical allusions in Menon, *op. cit.*, p. 23.

[2] *Cf.* Babylonian *Apsu*.

[3] Wall of the *Śiva* Temple at Tripālur (a village 12 miles off Palghat in the West Coast of S. India). The picture is accompanied by an inscription in Malayalam, describing the details; it appears to have been finished on May 9, 1846, by one Vasudevar, disciple of Maha Yogishwaraswami, a sage 'who dwells in the Sahya mountains, in Amalakakshetra, on Brahmagiri hill, in a sacred cave'. I am indebted to Mr. P. R. Chidambara Iyer of the Kodaikanal Observatory for bringing the above account to my notice.

All planets turn round their naves and travel like waves, so that rising and setting are observed. The moon alone revolves round the earth. Mars revolves beyond; Jupiter turns beyond in his own orbit with one loop per sign (Rasi). Beyond Saturn revolves with three loops per sign. *Rahu* and *Ketu* are latent in this. Above Saturn is the orbit of the Great Bear (*saptarshi* kakshi); above this is the orbit of the 27 Nakshatras, above this is the orb of the Pole-star.'

Then follow measures of the diameters of the globes and orbits of the Sun and the planets with particulars of the 'Winds' that blow them along in their orbits; and then a description of the 18 'Worlds' composing the cosmic-egg, of which Earth answers for 9 worlds, the world of Heaven includes the above 11 orbits, and there are eights beyond, ending with *Vaikuṇṭha* on the wall of this egg.

There are several peculiarities in this account. The postulation of several kinds of winds (Vāyu) as the agents causing the motion of the celestial bodies, the wave-like motion for the planets, and the mention of loops for Jupiter and Saturn are features of Hindu astronomy of the period of the Siddhāntas or earlier[1], rather than of the west. The rotation of the bodies including the earth and the place of the Sun at the centre are characteristic of western astronomy, though Aristarchos of Samos (3rd cent. B.C.) held the latter doctrine. But loops are not necessary in a heliocentric system; and though the earth is shown on the ecliptic, the writer gives the dimensions, not of the 'earth's orbit' but rather of the 'Sun's orbit'—which show that but for a superficial exchange of positions between the Sun and the Earth imposed later, the system is left intact in an early form. The division of the Universe into several worlds and the attribution of rectilinear orbits to two planets indeed indicate the very early origin of the system.

7. *The Orbit of Mercury.* It seems curious that the orbit of Mercury should have been supposed to be a five-pointed star; this figure was regarded by the Pythagoreans as endowed with mystical and occult qualities, and it was also employed in magic (*cf.* its name 'Wizard's Foot'). It is worth while trying to put oneself in the position of the early astronomer and explaining the phenomena with this orbit in view.

The main facts are:— (i) They would have observed that Mercury was never far off from the sun's direction, i.e. it oscillated round the line of sight to the Sun as a mean position, the maximum elongation (x) from the Sun being about 20° and the period being about 80 days.[2] (ii) They believed that Mercury

[1] 500 A.D. onwards. The 'motor' winds are described also in the Purāṇas (*cf.* Matsya-purāṇa 127, 12–17); these and the *vakra* and *anuvakra* motions were known to the Siddhāntas of the *Panchasidhāntika*.

[2] I.e. approximately. The modern figures are: x varies between 18° and 28° and period = 88 days.

moved along straight lines. From these two facts it would follow that during one of the stages of its journey, Mercury traces a line at right angles to the line of sight (say, from left to right) the extreme diections making $x°$ on either side of this line of sight; according to a crude manner of reckoning, the line of sight has to be stationary all this time. Then the planet retrogrades, i.e. moves from right to left; the line of sight in the meantime has moved through $2x$, and it will now be at right angles to the new path. For this orbit $2x = 36°$, so that $x = 18°$, i.e. the elongation of the planet was supposed to be 18°, which is near enough to the correct value.

We may understand the argument more graphically by reference to Fig. 5, in which the pentagonal orbit is derived by reducing the motion of Mercury round the Sun in a second circle [1] to rectilinear motion. (i) An observer standing at O and facing the direction OO_1 sees the planet retrograding from A to B, where $\angle AOO_1 = \angle O_1OB = 18°$; instead of the minor arc AB of the circle he believes that the planet traces the rectilinear path AHB at right angles to the line of sight OO_1 from left to right. And as the body continues its path on the circle and enters the major arc, it appears to reverse its direction and proceed from right to left. But by the time the planet has finished its retrogression, i.e. in 36 days (suppose), O_1 has gone forward to O_2 where $\angle O_1OO_2 = 36°$, and the point B of the circle centre O_1 now occupies the position A on circle centre O_2; the right to left motion of the planet therefore starts from A and proceeds along AC at right angles to the line of sight OO_2. When this is finished, OO_2 would have moved on to the position OO_3; the motion now is along the minor arc DC and appears to be retrograde along the chord DC at right angles to the new line of sight OO_3. The planet would then appear to move along DE and then along FE and so on. (ii) These bits of path AB, AC, DC etc. are disjointed, because of the alternating retrogression and progression. The astronomer could have of course known that the planet was not jumping across from B to A, etc., but was describing a continuous path. The obvious thing to do was to draw the 'map' of its motion on the ground or on a plank. This is obtained by drawing PQ in the direction of AB and equal to it; then QR in the direction of AC and equal to it; then RS $\|$ = DC; ST $\|$ = DE; and TP $\|$ = FE. This closes the circuit, and one obtains the five-pointed star PQRSTE for the orbit of Mercury.[2]

[1] I do not intend this to mean that the ancient astronomer actually supplied this "epicycle" as well as the rectilinear orbit. I have supplied the circle so that we may easily picture the argument.

[2] The same thing may be seen easily, if we suppose the Sun to be at O, and the observer at O_1, O_2, etc., on a revolving earth, moving through stages of 36° in separate periods of 36 days. Then he would see Mercury going along PQ, QR, etc., perpendicular to the lines of sight O_1O, O_2O,

There are naturally many oddities in the above argument, e.g. apart from the line of sight changing by stages, the times of progression and retrogression are equal, and the elongation (18°) as well as the period of Mercury (72 days) round the Sun are not accurate. But let us recall that the knowledge of the planets was very crude even in the times of the Ionian and

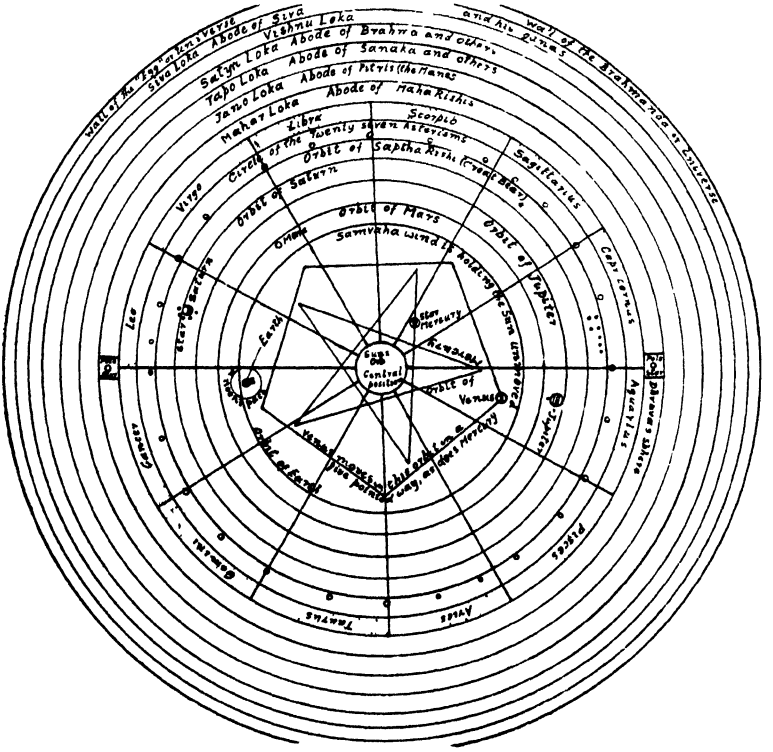


Fig. 4.

early Greek philosophers; even if the astronomer concerned with this pentagon had more accurate measurements at his disposal, his faith in sacred numbers and in regular figures would be so strong that he would regard the measurements as only approximations to the more perfect numbers 18, 36,[1] and 72.

etc., changing the direction of motion from progression to retrogression and *vice versa*, and with maximum elongation of 18° on either side.

[1] 18° = 3 units of the sexagesimal scale, and 36° = 6 units.

8. *The orbit of Venus.* If we attempted to explain the orbit of Venus in the same way, we find that one of the sides of the pentagon (say) a line of progression has to turn through an angle of 72°, when changing into the next side or line of retrogression, which means that the line of sight which is at right angles to the path must turn through (180°—72°) or 108° in the meantime. Therefore Venus was supposed to have a maximum elongation of 54° on either side of the line of sight to the Sun

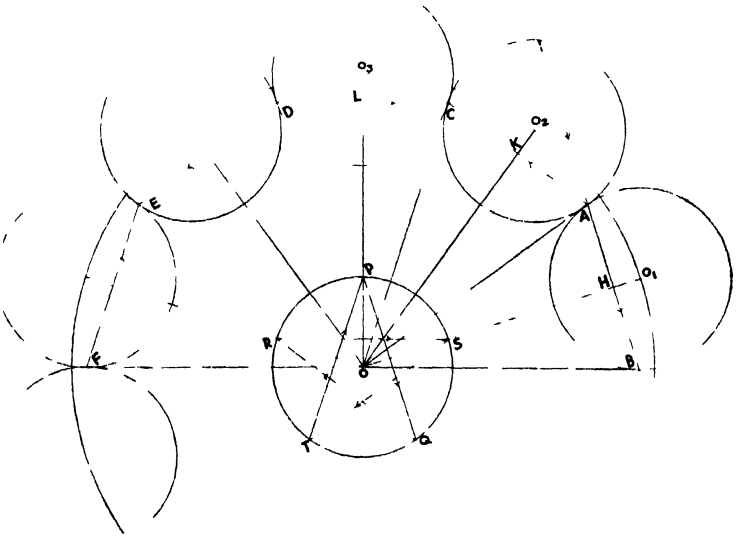


Fig. 5.

which turns through 108° in approximately 108 days, so that the period of Venus round the circle = 216 days.[1] This is near enough to the modern figure of 225 days. Neglecting any difference between these numbers and observed values as due to errors of observation[2], they might have argued as before and obtained the convex pentagon as the orbit of Venus.

9. *Other Cakras.* The above explanation of the orbits of Mercury and Venus lead us to attempt explanations of the other *Cakras* on the same lines.

[1] More accurately the period is $2 \times \frac{108}{100} \times 365\frac{1}{4}$ days = $219\frac{1}{7}$ days.

[2] There is nothing strange about this. Do we not do exactly the same thing when we neglect awkward decimals derived from observations and adopt simple numbers for our Laws, as for instance in the Inverse Square Law?

(i) The *Rāśi Cakra*[1] or the wheel of signs is, as stated in section 4, connected with the divisions of a square and the solar zodiac. The Ecliptic or the 'Year-cycle' of the Aryans, the Babylonian Furrow-of-heaven, was pre-eminently the orbit

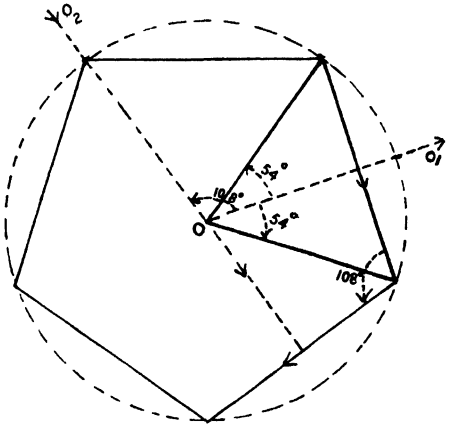


Fig. 6.

of the Sun. And it has been indicated above how this was represented by a square, and was probably regarded as a square. An explanation of the square orbit of the sun would be this:—

The Sun first travels along AB and then *turns* to BC; the line of sight turning through 90°. The motion of the Sun would then *appear* as an oscillation of 45° on either side of the

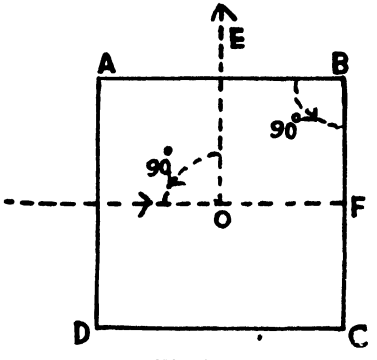


Fig. 7.

line of sight; this would be the case in places where the Sun rose N.E. at summer-solstice and S.E. at winter-solstice.

[1] *Cf.* Menon, *op. cit.*, p. 66 *et seq.*, 156 *seq.*

(ii) The *Rāhu Cakra* or the eight-pointed star is another important *Cakra* in astrology and magic. It is connected with the 'eight planets' (Sun, Moon and Rāhu being included amongst the planets) and especially with Rahu. The *Atharva-Veda* mentions Rāhu as a planet causing the eclipses; it was identified in later Hindu astronomy with the moon's ascending node; in mythology Rāhu was the head of the Demon or Serpent who swallowed the Sun and Moon during eclipses. *Rāhu Cakra* would thus appear to be connected with the motion of the moon's node. Whether it is concerned with the moon's node or not, if we argue as above, we see that Rāhu must have been imagined as travelling along AD and then turning through 135°, along DG. During a period of progression or retrogression, the line of sight turns through 180°—135° = 45°; so that Rāhu oscillates through $22\frac{1}{2}°$ on either side of a mean line; what was this mean line and what was the period of the oscillation it is hardly possible to conjecture.

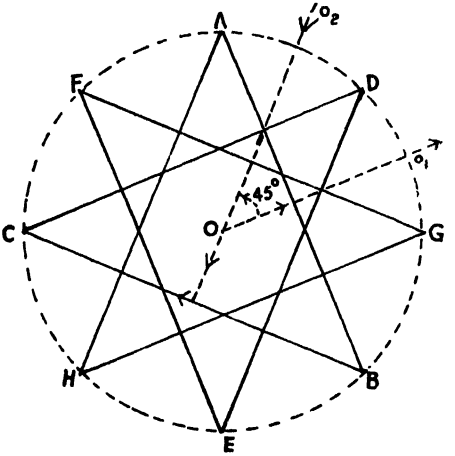


Fig. 8.

(iii) There are also other *Cakras* like the *Kurma-Cakra*, or the Tortoise-wheel which is a 27-pointed star, and the *Śri-Cakra*, the wheel of Lady Fortune, which is a 64-pointed star. A 27-pointed 'star' can be inscribed in a circle in four ways, two of which are illustrated here (see Fig. 9); the other two are obtained by continuously joining every two points separated by intervals of 10 points or 11 points. It is not certain which of these was drawn in early days, and so it is futile to attempt any explanation here. Al Biruni connects it with 27 nakshatras, but he gives no diagram. The 64-pointed star is identified with the Ecliptic and is used very much in magic.

10. *Shadow-measurement.* One is intrigued by the question why the ancient astronomer should have believed that the celestial bodies *actually moved* in straight lines. It is easier to understand the reason for their *representing* the motion by the square enclosure and its divisions. Now there is another practice of the ancient astronomers which seems to have gone hand in hand with the idea of rectilinear orbits, viz. their observation of the Sun by measuring the shadow cast on the ground. The connections of the square and its divisions or square bordors

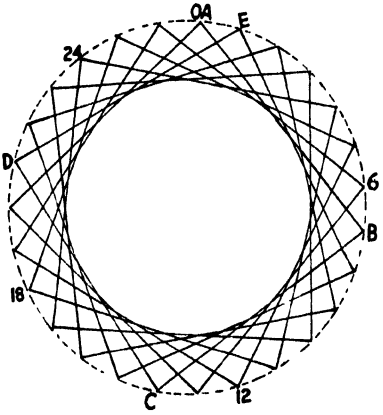


Fig. 9(*a*)

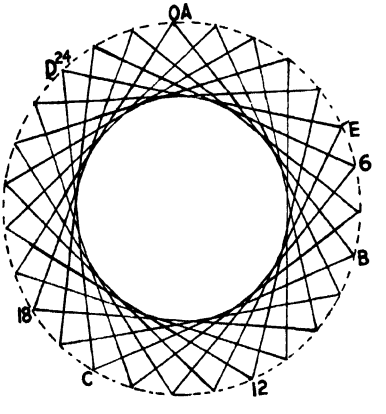


Fig. 9(*b*)

with (i) the gnomon which was used for measuring shadows [1]; (ii) with the Hindu myth of *Samjñā*, mistress of *C-hāyā* (shadow), and wife of *Sūrya* [2] (the Sun) and (iii) with the Biblical allusion to the shadow going back 10 *ma'aloth* (divisions or steps) on the dial of Ahaz and coming up again by an equal amount at the behest of Isaiah [3], have been explained by the present writer. The *Tcheou-pei*, which contained a description of a cosmology similar to that in the *Sūryaprajñapti*, gives measurements of the mid-day shadow on the longest and the shortest days of the year. So it is quite possible that they might have conceived of rectilinear paths by looking at the shadows.

The path of the tip of the equinoctial shadow of a vertical style on the ground is everywhere a straight line, viz. the line where a plane through the top of the style parallel to the celestial equator meets the horizontal plane. This can be proved by equations also.

Let Z, P, S be the zenith, pole and the Sun at any time. Let λ, δ, H, a be the latitude of the place, declination of the star,

[1] Menon, *op. cit.*, pages 44–46, 146, 147.
[2] *Ibid.*, pp. 146-147.
[3] *Ibid.*, pp. 149-150.

altitude and azimuth (measured for convenience on either side of the South meridian). Let H_0 be the meridian altitude on that day.

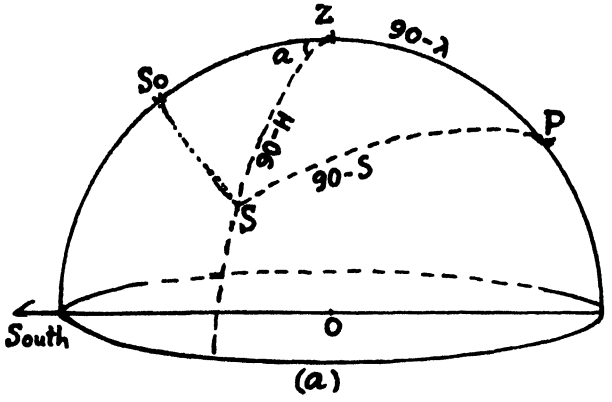


Fig. 10(*a*)

Then from spherical triangle ZSP.

$$\sin\delta = \sin H \sin\lambda - \cos H \cos\lambda \cos a \quad .. \quad (1)$$

When $H = H_0$,

$$\sin\delta = \sin H_0 \sin\lambda - \cos H_0 \cos\lambda \quad .. \quad (2)$$

Eliminating $\sin\delta$ between (1) and (2) we get an equation connecting H and $\cos a$ for the day.

On the equinoctial day, $\delta = 0$. Therefore (1) and (2) give

$$\cos a = \tan H \tan\lambda \quad .. \quad .. \quad (3)$$

$$1 = \tan H_0 \tan\lambda \quad .. \quad .. \quad (4)$$

$$\text{Therefore } \cot H \cos a = \tan\lambda = \cot H_0 \quad .. \quad (5)$$

Now, if p be the length of the style casting shadows,

$$\text{the shadow at Noon} = OA = p \cot H_0 \quad .. \quad (6)$$

and the shadow at S = $OQ = p \cot H$.

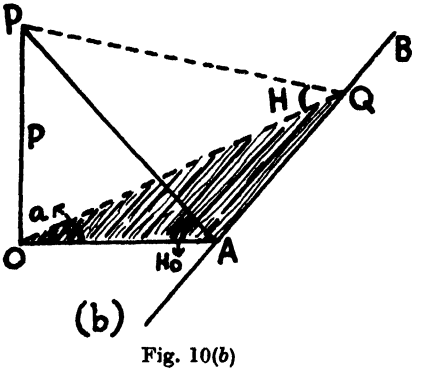


Fig. 10(*b*)

$$= \frac{p \cot H_0}{\cos a} \quad .. \quad .. \text{ by (5)}$$

$$= \frac{OA}{\cos a} \quad .. \quad .. \text{ by (6)}$$

But a is the angle QOA.
Therefore Q lies on AB drawn $\perp$ OA at A on the ground.
Thus the locus of the end of the shadow is a straight line.

This phenomenon is too striking to have escaped the notice of the shadow-measurers. They would also have noticed that for some time immediately after sun-rise [1], the top of the pole does not cast any shadow at all, and then the shadow begins to appear at a certain distance. From this they must have concluded that celestial bodies move in rectilinear orbits, and appear to us only when they come within a certain distance.

Conclusion.

11. Thus it would appear that the ancient astronomers who were engaged in observing the Sun and the stars and measuring the shadows learnt to assign rectilinear orbits to the celestial bodies. This fitted in with their system of measurements based on square scales, and with their general scheme of things including their conceptions like the Universe based on the square form and their appliances like the gnomon and the Sun-dial of Ahaz. From an evolutionary stand-point the square appears to have given place to the circle, the intermediate stages being marked by the pentagon, hexagon, octagon, etc.[2] While the solar orbit and the zodiac—the path of all the planets—was conceived as a square in the beginning, they soon began to differentiate the forms of the orbits of the planets: the pentagram and the pentagon were assigned to the orbits of Mercury and Venus, the eight-pointed star for Rāhu, and other stars for other entities; these were the polygons which formed the Ideal fits to the respective orbits, any variations in observed values being treated as approximations or mere appearances. These 'realities' or secrets of the Universe were treasured as secrets and gave rise to various symbols of mysticism, occultism and art, and survived in astrology, alchemy, the Kabbala, and in rites of religion and magic.

[1] I.e., till the Sun comes up to the height of the pole.
[2] *Cf.* Menon, *op. cit.*, pp. 49-50, 69, 74, 89, 167.

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ARTICLE NO. 7.

Observations on two Myxosporidians *Zschokkella lissemysi* N.Sp. from the gall-bladder of the tortoise, *Lissemys punctata* and *Zschokkella auerbachi* (Weill) from the gall-bladder of *Bufo melanostictus*, with a note on the Genus *Zschokkella* Auerbach.

By MUKUNDAMURARI CHAKRAVARTY.

(*Communicated by Dr. K. Biswas.*)

INTRODUCTION.

In the course of examination of the gall-bladder of the tortoise *Lissemys punctata* caught from the tank of our college compound, I came across a new species of *Zschokkella*, *Z. lissemysi* which is described in this paper. I have also given here a detailed description of *Zschokkella auerbachi* (Weill). A discussion on the genus *Zschokkella* has also been attempted here.

The methods of preparation adopted here are the same as given by the author (1939) in his previous paper. The spores were studied and their measurements taken in fresh conditions. Permanent preparations were also made in order to study the different developmental stages of the parasite.

I am indebted to Dr. H. N. Ray for his helpful suggestions and for the slides which he prepared and placed at my disposal for further investigation. Thanks are due to Mr. D. Mukerji and Mr. J. L. Bhaduri who helped me in various ways. Thanks are also due to Mr. P. L. Misra of Lucknow University for sending me some slides which he prepared from the gall-bladder of *Rana limnocharis* found at Mukteswar (U.P.).

Genus *Zschokkella* Auerbach 1910.

Since there is a considerable difference of opinion as to the proper use of the generic names *Cystodiscus* and *Zschokkella* a brief account of these genera as given by previous authors is given here. The genera *Cystodiscus* and *Zschokkella* were established by Lutz (1889) and Auerbach (1910) respectively to receive the type species *C. immersus* and *Z. hildae*. Cordero (1919) who re-examined *C. immersus* was of opinion that its spores resemble those of the genus *Myxidium*. Thus according to him *Cystodiscus* becomes a synonym of *Myxidium*. Weill (1929), however, ignoring the observations of Cordero pointed out that the characters of the spores of the genera *Cystodiscus* and *Zschokkella* resemble one another so much that he revived the genus *Cystodiscus* and merged Auerbach's genus *Zschokkella*

in it but curiously enough he admitted that the latter is well defined. In his revision of the myxosporidian genera Kudo (1933), especially on the strength of Cordero's observations, included *C. immersus* in the genus *Myxidium* abolishing the genus *Cystodiscus* and retained *Zschokkella* as a distinct genus.

I am in entire agreement with Kudo's classification but the definition of the genus *Zschokkella* needs a little emendation especially in reference to the characteristics of the spores. In the definition it is stated that the ends of the spores are pointed but on referring to some species of *Zschokkella* so far described it has been found that they are rounded as in *Z. ovata* (Dunkerly) 1921, *Z. rovignensis* Nemeczek 1922, *Z. parasiluri* Fujita 1927 and *Z. auerbachi* (Weill) 1929. The new species described in this paper also reveals rounded extremities of the spores. I therefore propose the following definition for the genus.

Genus *Zschokkella* Auerbach 1910 emend. Spore semicircular in front view; ellipsoidal in profile. Ends pointed or rounded. Sutural line curved. Polar capsules large and spherical; polar filaments long and fine. Typically coelozoic in marine or fresh-water fish and also in amphibians and reptilians.

Zschokkella lissemysi n.sp.

Host:—*Lissemys punctata* (Bonnaterre).

Habitat:—Gall-bladder.

Locality:—Calcutta.

Vegetative form:—In the stained preparations of the contents of the gall-bladder of the host a large number of amoeboid uninucleate forms (Pl. 4, figs. 1 and 2) were encountered. The cytoplasm of these young trophozoites is vacuolar and no distinction could be made between the ectoplasm and endoplasm. The nucleus is spherical with a centrally placed karyosome and measures about 2μ in diameter. The young trophozoites measure 12·36–14·42μ in length and 8·24–9·33μ in their broadest part. Mature or sporulating trophozoites were unfortunately not seen.

Spore: In front view, the spores appear semicircular (Pl. 4, fig. 3) with one of their ends slightly tapering and so they sometimes appear egg-shaped. In the lateral view they are ovoidal (Pl. 4, fig. 4). On the flat surface of the spore and in between the polar capsules there is a lid (Pl. 4, fig. 3), which, when open, in all probability allows the sporoplasm to flow out. The valves of the spore are thick and striated, the striae being parallel. The sutural line and ridge could not be seen. The polar capsules are equal and spherical. The coiled filament of the capsules can easily be seen in fresh condition. Each capsule is provided with a fine duct (Pl. 4, fig. 3) which opens to the exterior by the side of the lid. The filament is extruded through this duct. The sporoplasm occupies the entire space of the spore between the polar capsules and in front view extends dorsally

like an umbrella over the capsules. It is clearly visible both in fresh and stained conditions. In stained preparations two nuclei of the sporoplasm are found (Pl. 4, fig. 5) Besides, two capsulogenous nuclei are attached to the two capsules.

Dimensions: length of the spore 18·5–22·6μ, breadth of the spore 14·4–16·4μ, polar capsules 7·2–9·2μ in diameter, spore wall 2·06μ thick, polar filament 100μ in length.

Affinity.

Of all the species of *Zschokkella* so far known only one has been reported from the gall-bladder of Amphibia and the rest from the gall-bladder or urinary bladder or kidney of fishes. It is for the first time that *Z. lissemysi* is reported from the gall-bladder of a reptile. Its spores differ from those of all the known species of *Zschokkella* in the position of the polar capsules and in having a lid on the ventral wall of the spore by the sides of which the two ducts of the capsules open to the exterior. The spores of *Z. lissemysi* approach to those of *Z. hildae* Auerbach, and *Z. salvelini* Fantham, Porter and Richardson in size but differ in shape and in having rounded extremities. *Z. rovignensis* Nemeczek has spores equal in size with those of the parasite under report but differs in having one of the ends of the spores narrower than the other and in the presence of striations on the valves of the shell.

Zschokkella auerbachi (Weill)

Syn: *Cystodiscus auerbachi* Weill, 1929.
Zschokkella prasadi Ray, 1933*a*.
Cystodiscus sp. Ray, 1933.

Zschokkella auerbachi (Weill) was described in 1929 from the gall-bladder of *Bufo melanostictus* of the Indo-Chinese region. Ray (1933*a*) reported *Zschokkella prasadi* from the gall-bladder of *Bufo melanostictus* and *Rana tigrina* occurring in Calcutta but he published no description of the species. In the course of examination of the same hosts from the same locality as Ray (1933*a*) did, a species of *Zschokkella* was also observed by me to inhabit their gall-bladder. Ray very kindly handed over to me for further investigation the slides which he prepared and on comparing his preparations with those prepared by me, I find that these myxosporidians belong to the same species, as the shape and size of the spores as well as of the vegetative forms are exactly alike. Moreover the spores of the *Zschokkella* under report resemble very closely to those of *Z. auerbachi* (Weill) both in shape and size, although the size of the vegetative forms differs to a considerable extent. Thus, as the classification of myxosporidians are chiefly based on the characters of the spores, *Z. prasadi* as reported by Ray becomes synonymous with *Z. auerbachi*.

A careful examination of the preparations sent to me by P. L. Misra reveals that they are myxosporidians and this myxosporidian also resembles *Z. auerbachi* (Weill) in all essential features except that the spores are slightly bigger in size.

Description of *Zschokkella auerbachi* (Weill).

Host:—*Bufo melanostictus* Schneider, *Rana tigerina* Daud and *R. limnocharis* Wiegm.

Habitat:—Gall-bladder.

Locality:—Calcutta and Mukteswar (U.P.).

Vegetative form:—The mature trophozoites (Pl. 4, figs. 6 and 7) are irregular, some being oval in shape, others are disc-shaped while a few have an elongated amoeboid form. The young trophozoites (Pl. 4, fig. 8) are, however, circular in outline having a large number of nuclei and vacuolated cytoplasm. The nuclei (Pl. 4, fig. 10) contain a chromatin granule at their centre and vary from 3·1 to 4·2μ in diameter. Weill (1929) observed the difference between ectoplasm and endoplasm of the trophozoites, which, however, I failed to distinguish both in young and mature forms as well as in fresh and stained conditions. The outer wall of the trophozoites is composed of a thin, more or less hyaline matrix which is followed by a densely granular layer and a vacuolated inner layer (Pl. 4, fig. 9). The largest diameter of the circular and oval forms varies from 1·07 to 1·7 mm. while the elongated forms are 1 to 1·75 mm. in length and ·39 to ·5 mm. in width. The thickness of the trophozoites varies from 15–30μ. The size of the trophozoites given above differs very widely from those given by Weill.

Cell differentiation becomes marked with the growth of the parasites. Some of the cells (Pl. 4, fig. 12) develop into pansporoblasts which become differentiated first at the periphery of the trophozoites. As many as twelve nuclei could easily be counted within a pansporoblast (Pl. 4, fig. 13). Each pansporoblast gives rise to two sporoblasts (Pl. 4, figs. 14–16), each of which forms a single spore. Fully formed trophozoites contain a large number of spores which most probably escape by the rupture of the plasmodial forms. Hence the trophozoites are polysporous, the pansporoblasts disporoblastic and the sporoblasts monosporic.

Endogenous buds (Pl. 4, fig. 7) are developed within the developing plasmodial forms. First they appear as small uninucleate cells. The nucleus by its further division gives rise to a number of nuclei of uniform shape and size. When the endogenous buds attain the size of 40–60μ in diameter they migrate towards the periphery of the tropozoites and finally separate from the mother plasmodial form. Weill observed plasmogamy, which, however, was not seen by me.

Spore: The spores resemble the description given by Weill (1929). In front view, they are more or less semicircular (Pl. 4,

fig. 17) and ovoidal (Pl. 4, fig. 18) in side view. Both the ends of the spore are round, one of them is, however, narrower than the other. The shape of the spores appears different when viewed from different angles and this might have led Ray (1933) to call it a new species other than *Z. auerbachi*. The shell is thin and the valves are marked with striations. The sutural ridge is prominent and runs obliquely. The polar capsules are spherical being equal in size and they show distinctly coiled filaments in living conditions. The sporoplasm, which can equally be distinguished both in fresh and stained spores, is situated on the dorsal side of the spore and extends ventrally between the two polar capsules. It appears granular if the spores are stained and contains one or two nuclei (Pl. 4, figs. 20 and 21). The mononucleate spores are no doubt derived from the binucleate ones by the fusion of their nuclei. The size of the spores is approximately the same as given by Weill.

Dimensions: length of the spore 10·3μ, breadth of the spore 6·18μ, polar capsules 4·12μ in diameter, filament of the polar capsules 40–50μ in length. Dimensions of the spores obtained from *R. limnocharis*: length 12·36–14·42μ, breadth 6·18–8·24μ, polar capsules 4·12–5·21μ.

The table below shows a comparison between the original description given by Weill and the description given in this paper.

	Vegetative Form.		Spore.		
	Shape.	Size.	Shape.	Size.	Polar capsules.
Description given by Weill.	Discoidal; difference between ectoplasm and endoplasm.	50–180μ in diameter.	Regularly subspherical with angles rounded when seen from the side and ellipsoidal when seen from the surface.	11μ × 6μ.	Spherical in shape; 3μ in diameter; polar filamen 89-90μ long.
Description given by the present author.	Irregular; no difference between ectoplasm and endoplasm.	1000–1750μ in longest diameter.	Semicircular in side view; angles rounded but one end slightly tapering; ovoidal in side view.	10·3μ × 6·18μ and 12·36–14·42μ × 6·18–8·24μ.	Spherical in shape; 4·12μ in diameter; polar filament 40–50μ long.

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* Original paper not seen.

Explanations of Plate.

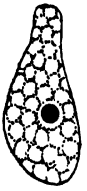
Figures were drawn under a camera lucida and magnified 1666 times, unless otherwise stated.

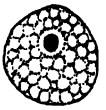
Zschokkella lissemysi n.sp., figs. 1–5.

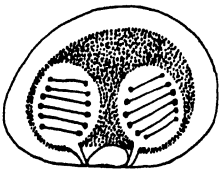
Figs. 1 and 2. Young trophozoites from a stained smear.
Fig. 3. Front view of a fresh spore, showing the position of the polar capsules with their ducts and the lid.
Fig. 4. Side view of a fresh spore, showing the striations on the shell.
Fig. 5. A spore from a stained smear.

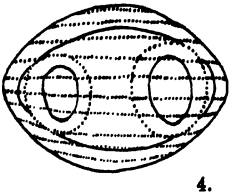
Zschokkella auerbachi (Weill), figs. 6–21.

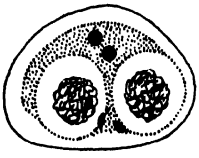
Figs. 6 and 7. Microphotographs of two stained mature trophozoites. Note in fig. 7, the endogenous buds, one of which is seen to separate from the mother plasmodial form on the right hand side. × 54.
Fig. 8. Microphotograph of a stained young trophozoite. × 710.
Fig. 9. Part of a stained trophozoite in section to show the three layers.
Fig. 10. A vegetative nucleus from a stained smear.
Fig. 11. A dividing vegetative nucleus from a stained smear.
Figs. 12–16. Development of spore from a stained smear; fig. 12 uninucleate pansporoblast; fig. 13 pansporoblast showing twelve nuclei; fig. 14 pansporoblast differentiated into two sporoblasts; figs. 15 and 16, development of a single spore within each of the sporoblasts.
Fig. 17 Front view of a fresh spore.
Fig. 18. Side view of a fresh spore.
Fig. 19. A fresh spore showing striations on the shell.
Figs. 20 and 21. Two stained spores from a stained smear. × 3500.

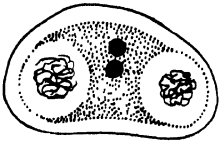

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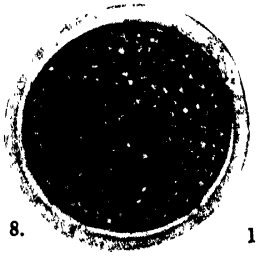

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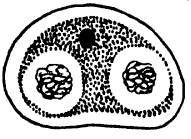

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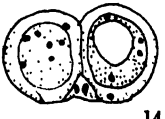

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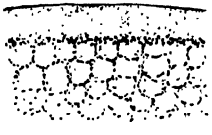

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ARTICLE No. 8.

On a Collection of Fish from Kalimpong Duars and Siliguri Terai, Northern Bengal.[1]

By SUNDER LAL HORA *and* J. C. GUPTA.

In 1938, Messrs. G. E. Shaw and E. O. Shebbeare published in the *Journal* of the Society (*Science*, III, pp. 1–137, text-figs. 1–130, pls. i–vi, 1937, December 1938) an illustrated account of the 'Fishes of Northern Bengal' and listed 131 species, a few of which are stated to be exotic as they had been purchased only from the markets at Siliguri and similar other places served by railway. All the same, the indigenous species of this region certainly number over one hundred. It has long been recognized that the fish-fauna of the Eastern Himalayas and the Assam Hills is very rich, for this area forms a meeting place of the Indo-Chinese, Indo-Malayan and Indian elements of the fish-fauna of the Oriental Region. The study of the fishes of northern Bengal is, therefore, of special interest from a zoogeographical point of view. Moreover, a fair number of freshwater species described by Hamilton in his *Gangetic Fishes* were obtained from northern Bengal and to elucidate their precise taxonomic position one has to rely, in the absence of types, on topotypes. In view of these considerations, the Zoological Survey of India had been trying for some years to obtain well preserved specimens of fishes from this region for its collection in the Indian Museum. However, a good opportunity to study this fauna occurred when in November-December, 1938, one of us (S. L. Hora) led a party of the Zoological Survey of India to the Kalimpong Duars and the portion of the Terai in the Siliguri Sub-Division of the Darjeeling District, and collections of fish were made from a large number of small streams, ponds and ditches. The party visited Mongpong, Chunbhati, Ghish and Burrikhola in the Kalimpong Duars, and Siliguri, Sevoke, Kalijhora, Naksalbari and Kharibari in the Siliguri Sub-Division.

The country surveyed was almost level or slightly undulating here and there, but it was cut up by innumerable small streams and *nallahs* which carry large volumes of water during the rains but become reduced to a small stream or a mere trickle during the dry season. Some of the streams flowed through vast arid expanses, while the valleys of others were well shaded with thick forests. The beds of these streams were often pebbly or sandy and only in a few cases the sides were steep and rocky.

[1] Published with permission of the Director, Zoological Survey of India.

Here and there deep pools occurred, but generally the water was clear and shallow. There was very little aquatic vegetation except for algae covering rocks or stones, or floating in side-pools.

From the types of localities visited by the party, the fish-fauna can be divided into two principal ecological associations. The first association comprises pool-dwelling forms, such as *Danio aequipinnatus* (McClelland), *D. dangila* Hamilton, *D. devario* Hamilton, *Brachydanio rerio* (Hamilton), *Esomus danricus* (Hamilton), *Barbus* (*Puntius*) *conchonius* Hamilton, *B.* (*Puntius*) *sophore* Hamilton, *B.* (*Puntius*) *ticto* Hamilton, *Mystus vittatus* (Bloch), *Xenentodon cancila* (Hamilton), *Ambassis ranga* (Hamilton), *Badis badis* (Hamilton), *Ophicephalus gachua* Hamilton, *O. punctatus* Bloch, *Colisa chuna* (Hamilton), etc., etc. These can be further divided into two categories—those that live in clear water pools in the course of the streams and those that live in stagnant pieces of water. Some of the species are adapted to both types of habitats. The second association comprises those species that live in shallow swift currents, and here again we have certain fishes, such as loaches and loach-like catfishes which live among pebbles at the bottom, and certain others which live in rapids by sheer muscular efforts. The fishes of the second category comprise Mahseers, of which three distinct types were collected by the party.

In making a collection of fishes, small streams were dammed across and their waters diverted. In the drying up channels below the dams a great variety of fishes were collected by turning over rocks and stones. A small bag-net was also used in catching fish from ponds and ditches, and deeper parts of streams. Attention may also be directed to the fact that almost all the species in the collection are represented by very young specimens which shows that the fish in this part of the country breed during or immediately after the monsoon months.

The following species of fish were obtained by the party:—

Family: CYPRINIDAE.

Subfamily: *ABRAMADINAE.*

1. *Chela bacaila* Hamilton.

Subfamily: *RASBORINAE.*

2. *Barilius barna* Hamilton.
3. *Barilius bendelesis* Hamilton.
4. *Barilius* (*Opsarius*) *bola* Hamilton.
5. *Barilius shacra* Hamilton.
6. *Barilius vagra* Hamilton.
7. *Danio aequipinnatus* (McClelland).
8. *Danio dangila* Hamilton.
9. *Danio devario* Hamilton.

10. *Danio* (*Brachydanio*) *rerio* Hamilton.
11. *Esomus danricus* (Hamilton).

Subfamily: *CYPRINAE*.

12. *Aspidoparia jaya* (Hamilton).
13. *Aspidoparia morar* (Hamilton).
14. *Barbus* (*Chagunius*) *chagunio* (Hamilton).
15. *Barbus* (*Puntius*) *conchonius* Hamilton.
16. *Barbus* (*Lissochilus*) *hexagonolepis* McClelland.
17. *Barbus* (*Tor*) *putitora* (Hamilton).
18. *Barbus* (*Puntius*) *sarana* (Hamilton).
19. *Barbus* (*Puntius*) *sophore* Hamilton.
20. *Barbus* (*Puntius*) *ticto* Hamilton.
21. *Barbus* (*Puntius*) *titius* Hamilton.
22. *Barbus* (*Tor*) *tor* (Hamilton).
23. *Crossochilus latius* (Hamilton).
24. *Garra annandalei* Hora.
25. *Garra gotyla* (Gray).
26. *Labeo dero* (Hamilton).
27. *Labeo dyocheilus* (McClelland).
28. *Semiplotus semiplotus* (McClelland).

Subfamily: *SCHIZOTHORACINAE*.

29. *Oreinus molesworthii* Chaudhuri.

Family: PSILORHYNCHIDAE.

30. *Psilorhynchus balitora* (Hamilton).
31. *Psilorhynchus sucatio* (Hamilton).

Family: COBITIDAE.

32. *Aborichthys elongatus* Hora.
33. *Acanthophthalmus pangia* (Hamilton).
34. *Lepidocephalus guntea* (Hamilton).
35. *Nemachilus beavani* Günther.
36. *Nemachilus botia* (Hamilton).
37. *Nemachilus devdevi* Hora.
38. *Nemachilus rupicola* var. *inglisi* Hora.
39. *Nemachilus savona* (Hamilton).
40. *Nemachilus scaturigina* (McClelland).
41. *Somileptes gongota* (Hamilton).

Family: OLYRIDAE.

42. *Olyra longicaudata* McClelland.

Family: SILURIDAE.

43. *Silurus cochinchinensis* Cuvier and Valenciennes.

Family: SCHILBEIDAE.

44. *Clupisoma garua* (Hamilton).

Family: BAGRIDAE.

45. *Batasio batasio* (Hamilton).

46. *Batasio tengana* (Hamilton).
47. *Mystus vittatus* (Bloch).

Family: AMBLYCEPIDAE.

48. *Amblyceps mangois* (Hamilton).

Family: SISORIDAE.

49. *Laguvia shawi* Hora.

Family: XENENTODONTIDAE.

50. *Xenentodon cancila* (Hamilton).

Family: AMBASSIDAE.

51. *Ambassis baculis* (Hamilton).
52. *Ambassis ranga* (Hamilton).

Family: NANDIDAE.

53. *Badis badis* (Hamilton).

Family: GOBIIDAE.

54. *Glossogobius giuris* (Hamilton).

Family: OPHICEPHALIDAE.

55. *Ophicephalus gachua* Hamilton.
56. *Ophicephalus punctatus* Bloch.

Family: OSPHRONEMIDAE.

57. *Colisa chuna* (Hamilton).

Family: MASTACEMBELIDAE.

58. *Mastacembelus armatus* (Lacépède).

To the species listed by Shaw and Shebbeare from northern Bengal, we have added three more species, *viz. Barbus* (*Tor*) *tor* (Hamilton),[1] *Batasio tengana* (Hamilton),[2] and *Ambassis baculis* (Hamilton). *Barbus* (*Lissochilus*) *hexagonolepis* McClelland[3] of our list is the same as *Barbus dukai* Day of the list of Shaw and Shebbeare, *Barbus* (*Puntius*) *sophore* Hamilton[4] is the same as *B. stigma* (Cuv. and Val.), and *Olyra longicaudata* McClelland[5] is the same as *O. kempi* Chaudhuri. In the course of our revision we have also found it necessary to make alterations in the generic or subgeneric names of certain species listed by Shaw and Shebbeare; these are *Barilius* (*Opsarius*) *bola*

[1] Hora, S. L.—*Journ. Bombay Nat. Hist. Soc.*, XLI, pp. 518–525, 3 pls., 1 text-fig. (1940).

[2] Hora, S. L. and Law, N. C.—*Rec. Ind. Mus.*, XLIII, pp. 36–39, pl. ii, figs. 1–3, (1941). The taxonomic position of *Batasio* (Blyth) is also discussed in this article.

[3] Hora, S. L.—*Journ. Bombay Nat. Hist. Soc.*, XLII, pp. 78–88, 1 pl., 4 text-figs. (1940).

[4] Chaudhuri, B. L.—*Mem. Ind. Mus.*, V, pp. 436–438 (1916).

[5] Hora, S. L.—*Rec. Ind. Mus.*, XXXVIII, pp. 202–207 (1936).

Hamilton,[1] *Barbus* (*Chagunius*) *chagunio* (Hamilton),[2] *Clupisoma garua* (Hamilton),[3] and *Colisa chuna* (Hamilton). Further, it has been found that *Lepidocephalus annandalei* Chaudhuri is a juvenile colour form of *L. guntea* (Hamilton). Notes on the variation of the dorsal spine of *Semiplotus semiplotus* (McClelland) and on the systematic position of *Barbus* (*Puntius*) *titius* Hamilton are given. In well preserved specimens of *Laguvia shawi* Hora there is a distinct adhesive pad in the chest region similar to that of the species of *Glyptothorax* Blyth.

Lepidocephalus guntea (Hamilton).

1878. *Lepidocephalichthys guntea*, Day, *Fish. India*, p. 609, pl. clv, fig. 4.
1912. *Lepidocephalichthys annandalei*, Chaudhuri, *Rec. Ind. Mus.*, VII, p. 442, pl. xl, figs. 3, 3*a*, 3*b*.
1938. *Lepidocephalichthys annandalei*, Shaw and Shebbeare, *Journ. Roy. As. Soc. Bengal, Science*, III, p. 67, text-fig. 64.
1938. *Lepidocephalichthys guntea*, Shaw and Shebbeare, *ibid.*, p. 68, text-fig. 65, pl. ii, fig. 2.

Lepidocephalus guntea is represented in the collection by a very large number of specimens. As has been noted by previous workers, the colouration varies considerably with the size and habitat of the individuals. In a number of young specimens, there are two ocelli in connection with the caudal fin which are situated exactly in the same positions as described by Chaudhuri for his *L. annandalei*. In other respects also the colouration of the juvenile examples agrees with that of Chaudhuri's species. For these reasons we regard the two species as conspecific.

Semiplotus semiplotus (McClelland).

1937. *Semiplotus semiplotus*, Shaw and Shebbeare, *Journ. Roy. As. Soc. Bengal, Science*, III, p. 59, text-fig. 56, pl. v, fig. 8.
1937. *Semiplotus semiplotus*, Hora, *Rec. Ind. Mus.*, XXXIX, pp. 45, 46.

Semiplotus semiplotus is represented in the collection by 15 young examples ranging in standard length from 17 to 107 mm. All the specimens possess small maxillary barbels which are more pronounced in smaller individuals (*vide* Hora, *loc. cit.*, pp. 45, 46). In the three specimens collected from the Joyranti Stream, 33 to 38 mm. in standard length, the distal half of the dorsal spine is slightly serrated, but in all other respects they agree with the remaining young examples, in which the dorsal spine is smooth throughout. The dorsal spine

[1] Hora, S. L.—*Journ. Bombay Nat. Hist. Soc.*, XXXIX, pp. 199–210, 1 pl., 3 text-figs. (1937).
[2] Smith, H. M.—*Proc. Biol. Soc. Washington*, LI, pp. 157, 158 (1938).
[3] Hora, S. L.—*Journ. Bombay Nat. Hist. Soc.*, XXXIX, pp. 659–678, 1 pl., 9 text-figs. (1937).

is also slightly serrated in a specimen, about 67 mm. in length, from the Mahanadi River.

In connection with the structure of the dorsal spine noted above, attention may be directed to the fact that the only other species of the genus, *S. modestus* Day [1] from Burma, is characterized by a serrated dorsal spine. It seems probable that the serrated dorsal spine in the juvenile examples of *S. semiplotus* referred to above is an embryonic or atavistic character, and indicates that *S. modestus* is probably a less specialized member of the genus than *S. semiplotus*.

Barbus (Puntius) titius Hamilton.

1822. *Cyprinus titius*, Hamilton, *Fish. Ganges*, p. 315.
1839. *Systomus tetrarupagus*, McClelland, *Ind. Cyp.*, pp. 285, 381, pl. xliv, fig. 3.
1868. *Barbus titius*, Günther, *Cat. Fish. Brit. Mus.*, VII, p. 154.
1878. *Barbus tetrarupagus*, Day, *Fish. India*, p. 572, pl. cxlii, fig. 5.
1889. *Barbus tetrarupagus*, Day, *Faun. Brit. Ind., Fish.*, I, pp. 318, 319.
1937. *Barbus titius*, Shaw and Shebbeare, *Journ. Roy. As. Soc. Bengal, Science*, III, p. 44, text-fig. 39, pl. v, fig. 5.
1939. *Barbus tetrarupagus*, Das, *Rec. Ind. Mus.*, XLI, p. 441.
1940. *Barbus (Puntius) tetrarupagus*, Hora, *Rec. Ind. Mus.*, XLII, p. 370.

Cyprinus (*Puntius*) *titius* was 'found in ponds near Calcutta', but insufficiently characterized by Hamilton, who on account of its utmost resemblance with *C. ticto* 'did not think it necessary to take a drawing or particular description of the Calcutta kind'. However, he distinguished the species mainly on the position of colour spots; in *C. ticto* there is 'one black spot on the lateral line above each pectoral fin, and another near the end of the tail; and with the back fin spotted', while *C. titius* is provided 'with two black spots on each side, near the lateral line; with no spots on the dorsal fin'. Another important difference that can be readily made out from Hamilton's descriptions of the two species is in the nature of their dorsal spine; in *C. ticto* it is indented behind while in *C. titius* it is smooth. McClelland doubtfully referred *C. titius* to his *Systomus tetrarupagus* which he characterized by the possession of 'a black spot on either side behind the opercula and another at the end of the tail' and remarked (foot-note, p. 285) '*Cyprinus ticto* (Buch). P.G. t.8.f.87, is nearly allied to this species, but shorter'. Though Günther regarded Hamilton's species as valid, with *Systomus tetrarupagus* as its synonym, Day considered both the species doubtful. However, Day adopted the specific name *tetrarupagus* for describing this species. Recently Das and Hora followed Day, but Shaw and Shebbeare had rightly described the species under its original name.

[1] Day, F.—*Fish. India*, p. 550, pl. cxxxiii, fig. 1 (1877).

B. (*Puntius*) *titius* is a characteristic species and is represented in the collection by two adult specimens 56 mm. and 68 mm. in standard length respectively; it can be readily distinguished by its colour spots. According to Day, *B. tetrarupagus* it is found in 'Orissa, Bengal, Assam, N.W. Province, Punjab, and Sind, also the Deccan'.

Summary.

Attention is directed to the great importance of the study of the fish-fauna of the Eastern Himalayas and notes are given on the physical conditions of the parts of the Kalimpong Duars and of the Siliguri Terai in which collections were made. The fish-fauna is roughly divided into ecological associations and a reference is also made to the methods of collecting fish.

A list of 58 species is given and additions and alterations made in a list of 131 species of fish of northern Bengal published by Messrs. Shaw and Shebbeare in 1938 are explained. Taxonomic notes are given on *Lepidocephalus guntea* (Hamilton), *Semiplotus semiplotus* (McClelland), and *Barbus* (*Puntius*) *titius* Hamilton.

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Volume VI, 1940.

ARTICLE NO. 9.

A Note on the History of Bacteriology and some of the Early Workers in India.

By MAJOR C. L. PASRICHA, I.M.S.

This short communication is prepared from some notes and analyses made during the course of reading Bulloch's (1938) history of bacteriology. At the end of this excellent and valuable book there are biographical notices of some of the early workers in bacteriology. In this are listed 330 bacteriologists and others whose work contributed to the development of bacteriology. The nationality of these pioneer workers was analyzed and is given in Table I.

TABLE I.

The Nationality of the 330 Early Workers in Bacteriology.

Nationality.	Number.	Percentage of total.
German	113	34·24
English	58	17·58
French	55	16·66
American	24	7·27
Austrian	16	4·85
Italian	15	4·55
Danish	8	2·42
Russian	8	2·42
Hungarian	5	1·51
Japanese	5	1·51
Swiss	4	1·21
Dutch	3	0·91
Belgian .. .	3	0·91
Canadian	2	0·6
Rumanian	2	0·6
Polish	2	0·6
Portuguese	1	0·3
Spanish	1	0·3
Norwegian	1	0·3
Ukrainian	1	0·3
Yugo-Slavian ..	1	0·3
Lithuanian	1	0·3
Maltese	1	0·3

Table II.

The number of workers in each decade (except the last decade) during the nineteenth century.

Decade ending.	German.	English.	French.	American.	Austrian.	Italian.	Danish.	Russian.	Hungarian.	Japanese.	Swiss.	Dutch.	Belgian.	Canadian.	Rumanian.	Polish.	Portuguese.	Spanish.	Norwegian.	Ukrainian.	Yugo-Slavian.	Lithuanian.	Maltese.	Total.
1810	8	..	5	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14
1820	4	5	5	1	..	2	1	..	..	..	1	1	..	.	..	..	..	..	..	..	..	..	..	20
1830	5	4	5*	..	* Pasteur born.				..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14
1840	12	2	6	1	..	..	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	21
1850	26	7	8	2	2	1	2	1	2	.	..	.	..	..	..	1	..	1	1	..	1	..	..	55
1860	32	13	8	8	5	5	1	3	1	2	2	1	1	..	..	1	..	..	..	1	..	..	..	84
1870	14	18	6	8	6	1	2	3	..	1	1	..	1	1	..	..	1	..	..	..	..	..	1	64
1880	5	5	..	4	1	1	..	..	1	2	..	..	..	1	1	..	..	..	..	..	..	1	..	22
1890	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	2
Total	107	54	43	24	14	10	6	7	5	5	4	2	2	2	2	2	1	1	1	1	1	1	1	296

The rapid development of bacteriology in the second half of the nineteenth century is well seen in Table II in which is given the number of workers in successive decades during the 19th century (except the last decade). It is interesting to note that a marked increase in the number of workers occurs two decades after the birth of Pasteur.

There are listed 29 workers born earlier than 1800 (one each in the 15th and 16th centuries, nine in the 17th century and eighteen in the 18th century). There are five workers whose date of birth is unknown leaving a total of 296 workers born in the 19th century. These have been analyzed according to their nationality and the decade in which they were born.

Of the 330 early workers in bacteriology listed by Bulloch seventeen came to India. These workers are listed below alphabetically together with some notes of the work done by them and references where further information can be found.

Early workers in Bacteriology who came to India.

1. Carter, Henry Vandyke (British, born 1831, died 1897).

Joined the Indian Medical Service in 1858 and was Professor of Anatomy and Physiology in Grant Medical College, Bombay (from 1858 to 1863). Worked at leprosy, mycetoma, surra, malaria and relapsing fever. Whilst a demonstrator of anatomy in St. George's Hospital drew the illustrations for Gray's Anatomy. In an obituary notice in the British Medical Journal (1897) is found a true epitaph of this worker. 'Carter devoted his life, his talents, his pen and his pencil unsparingly and unflaggingly to the service of science and of India'. In recognition of his work on relapsing fever Carter received the Stewart Pathological Prize of £500 awarded by the British Medical Association.

Brit. Med. Journ., 1897 (i), 1256.
Lancet, 1897 (i), 1381.

2. Cunningham, David Douglas (British, born 1843, died 1914).

Entered the Indian Medical Service in 1868 and in company with Lewis went to Germany to learn the views and master the technique of Hallier and De Bary, and to work for a time under Pettenkofer at Munich. Cunningham and Lewis reached Calcutta in 1869 and for the next ten years both were engaged in important pathological and hygienic studies. With Timothy Lewis made exhaustive study of cholera in India. Cunningham became Professor of Physiology and for a time also of Pathology in Calcutta Medical College. During his residence in India Cunningham was at frequent intervals a councillor of the Asiatic Society of Bengal. He was for many years one of the trustees of the Indian Museum and an active member (later the Chairman) of the committee of management of the Calcutta Zoological Garden. It was on his suggestion and in accordance with his plans that a research laboratory was established in the Zoological gardens. He was elected F.R.S. in 1889, awarded C.I.E. in 1893 and retired in 1899.

Brit. Med. Journ., 1915 (i), 98 and 141.
Proc. Roy. Soc. London, 1916, B LXXXIX, 15–20.

3. DOUGLAS, STEWART RANKEN (British, born 1871, died 1936).

Joined Indian Medical Service 1898. Served in China expedition 1900-1. Retired from the I.M.S. with rank of Captain. Came into close association with Sir Almroth Wright and worked with him for several years. Studied the serological grouping of vibrios. Later became Director of Bacteriological Department of the National Institute of Medical Research. F.R.S. in 1922.

Lancet, 1936 (i), 229.

4. FISCHER, BERNHARD (German, born 1852, died 1915).

Assistant to Koch in Berlin and come with him on the Cholera Commission to India (1883).

Deut. med. Woch, 1915, xli, 1165.

5. GAFFKY, GEORGE (German, born 1850, died 1918).

Pupil, assistant, and successor of Robert Koch in Berlin. Accompanied Koch on German Cholera Commission to India (1883). Studied cholera in Hamburg 1892. Head of the German Plague Commission in India, 1897.

Berl. Klin. Woch, 1918, lv, 1062.
Deut. med. Woch, 1918, xliv, 1199.
Munch. med. Woch, 1918, lxv, 1191.

6 HAFFKINE, WALDEMAR MORDECAI WOLFF (Ukrainian, born 1860, died 1930).

Trained in Pasteur Institute, Paris, (1888–93) during a time when special study was being made of the preparation of vaccines and their application to prophylactics. An immense impetus had been given to this line of research by Pasteur's great experimental demonstration of the value of his vaccine against anthrax. Haffkine arrived in Calcutta in March 1893 and from here he travelled across to different places in India. In the first year he inoculated about 25,000 persons with his cholera vaccine. In 1894 he returned to Calcutta and carried out a large number of inoculations. In 1896 Haffkine went to Bombay and there produced a plague prophylactic vaccine and used it on a gigantic scale. Haffkine's name will always be associated with both cholera and plague prophylaxis. Founded Government Research Laboratory (now Haffkine Institute), Bombay. Retired in 1915.

Brit. Med. Journ., 1930 (ii), 801.

7. HANKIN, ERNEST HANBURY (British, born 1865).

Wrote early papers on nature of immunity and alexins. Was Chemical Examiner and Bacteriologist to the United Provinces and to the Central Provinces and worked on cholera, particularly the isolation of vibrios from natural waters and noted 'degenerative' forms of vibrios. He also worked on the epidemiology of plague.

8. D'HERELLE, FELIX HUBERT (Canadian, born in Montreal, 1873).

Chiefly known for his work on bacteriophage. Came to India in 1928 when during his short stay he worked extensively on cholera and dysentery bacteriophages.

9. KOCH, ROBERT (German, born 1843, died 1910).

The greatest pure bacteriologist and as Nuttall puts it 'In the annals of medicine his name should be enrolled with the immortals'. Koch first came to India in 1883 and he was one of the first to suggest that human malaria is transmitted

by mosquitoes. It was Koch who first advocated the systematic use of quinine in combating malaria, for he conceived that this disease could be eradicated by discovering the infected persons in a community and subjecting them to radical treatment thereby ridding them of parasites and rendering them no longer capable of infecting the anopheline vectors. Koch continued his study of cholera and in Calcutta he confirmed and extended the observations begun in Egypt and was able to announce the discovery of the cholera vibrio. Koch's work on cholera has scarcely been surpassed to this day. It must be remembered that he worked as a pioneer with the simplest of means. Considering the very great importance of this discovery which paved the way to a clear understanding of the etiology and prevention of this one of the most important scourges of India, it is to be regretted that there exists no memorial to commemorate the great service Koch rendered to this country. In 1896 at the age of 53 Koch came again to India, this time to Bombay as the head of the German Plague Commission.

Journ. Path. and Bact., 1910-11, XV, 108.
Parasitology, 1924-25, XVI, 214–38.
Proc. Roy. Soc., 1910-11, LXXXIII, Supp. 18–24.

10. LAMB, GEORGE (British, born 1870, died 1911).

Member of the Indian Medical Service. Came to India in 1894. Later assistant to Haffkine in Bombay and made important studies of snake venoms. Subsequently became Director of Pasteur Institute in India and initiated important modifications in the treatment of hydrophobia. Lamb carried out extensive investigations on Malta fever in India, on transmission of plague by fleas, and on rabies. For his work on plague he received the Stewart Prize awarded by the British Medical Association.

Journ. Hyg. (*Plague Suppl.*), 1912, XII, 2.
Journ. Path. and Bact., 1911, XVI, 119.
Brit. Med. Journ., 1911 (i), 969, 1029.

11. LEISHMANN, WILLIAM BOOG (British, born 1865, died 1926).

Joined the Royal Army Medical Corp., 1887. Rose to be Director-General of Army Medical Services. It was during his service in India that he began to take a close interest in bacteriology, especially in relation to dysentery with which he found himself in perpetual contact. Whilst stationed at Netley came under the influence of Almroth Wright. He assisted Wright in the early work on typhoid vaccine and made some investigations into Malta fever, a disease which later he contracted himself in the laboratory. It was here that whilst working with Wright on vaccine therapy that Leishmann introduced his stain which has now superseded its predecessor, the Romanowsky stain. Distinguished for his work on the value of anti-typhoid inoculation, phagocytosis and Leishmaniasis. F.R.S. in 1910.

Lancet, 1926 (i), 1171–8.

12. LEWIS, TIMOTHY RICHARDS (British, born 1841, died 1886).

Joined Army Medical Service and came to India (1869). He studied cholera in collaboration with Cunningham. In 1870 gave the first authentic account of amoebae from the human intestine found in cholera evacuations. In 1872 he gave the first account of 'Filaria sanguinis hominis'. He

gave the first description of rat trypanosoma now called T. lewisi.

Parasitology, 1923, xiv, 413.
Ind. Med. Gaz., 1886, XXI, 179, 249.
Brit. Med. Journ., 1886 (i), 1242.
Nature, 1886, xxxiv, 76.

13. LUSTIG, ALESSANDRO (Italian, born 1857, died 1937).

Studied plague in India and introduced a method of preventive inoculation against this disease.

Garz. d. osp., 1937, LVIII, 960.

14. MARTIN, CHARLES JAMES (British, born 1866).

Studied plague particularly the mechanism of the transmission of plague by fleas. Was a member of the Plague Advisory Committee. He also worked on the insect porters of bacterial infections.

15. PFEIFFER, RICHARD (German, born 1858).

1896 served on the German Plague Commission in India. Discovered specific lysis of cholera (Pfeiffer's reaction).

Munch. Med. Woch, 1928, LXXV, 524.

16. ROWLAND, SYDNEY DOMVILLE (British, born 1872 died 1917).

Came to India 1905 as a member of the Advisory Committee for Plague Investigation in India and worked in the laboratory at Parel. His more special share in the activities of the working Commission in India was the laboratory work on the relation between fleas and plague. Later in England worked in the preparation of curative sera for plague.

Journ. Path. and Bact., 1916-17, XXI, 453.
Lancet, 1917, (i), 552.

17. WRIGHT, ALMROTH EDWARD (British, born 1861).

1898–1900 Member of Indian Plague Commission when with Dr. Ruffer wrote an important note of dissent (on the measures for the discovery of plague deaths) to the conclusions arrived at by the Indian Plague Commission. Pioneer in typhoid inoculations and developed the subject of therapeutic immunization generally. Responsible also for the training of a band of workers who were imbued with enthusiasm for research by coming in contact with Almroth Wright. Many of the workers in India owed much to the inspiration gained from this teacher.

It was hoped to write of these workers at greater length, to make fuller summaries of the work done by them and to build up a connected story, but other engrossing, more important and urgent duties render this impossible for the present. Suffice it to say that each one of them has left an indelible mark upon the annals of research and discovery in relation to infectious diseases of man and animals. The work done by these pioneer workers has borne, is bearing and will bear much fruit. To take but one instance it was Koch's discovery of the cholera vibrio and the pioneer work of Wright and Leishmann with typhoid vaccine that led to the subsequent large-scale trials under controlled conditions of cholera vaccine by Haffkine. These experiments contributed in no small measure to the establishment of the

value of vaccines as prophylactic agents in the controlling of large epidemic diseases. If it were possible to reckon up the sum of human lives that have been saved from premature death by this procedure alone the total would attain gigantic proportions. India has played an important rôle in two ways, firstly the presence of epidemic diseases and secondly the facilities for large scale trials under controlled conditions and with reasonable facilities for collecting data. The fact that of the 330 early workers who have found place in Bulloch's history of bacteriology seventeen workers came to India is sufficient justification for India to feel proud of the facilities that she has been able to offer these workers and thus to the development of the science of bacteriology. For her part India and her present-day workers should ever keep these men in grateful memory.

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Journal Royal Asiatic Society of Bengal. Science.

Volume VI, 1940.

ARTICLE NO. 10.

Life-History and Wanderings of *Hilsa* in Bengal Waters.[1]

By SUNDER LAL HORA.

"To study the wants of a people, to inquire into the history, language, habits, and customs of a nation, is generally deemed a duty on the part of its rulers: but hardly any objects of research are more worthy of the attention of a Government than the sources whence the food of the population is derived, or the nature of the articles most adapted for its manufacturing processes, or best fitted in the raw state for its home or foreign trade. In India the details of Native agriculture have been carefully studied, if they have not been improved; the earth has been ransacked for its minerals; the forests have been explored for their timber; the land for its agricultural capabilities, even the atmosphere for its meteorological variations; and in all these matters Government has wisely shown its interest; but the fish with which the fresh waters of Hindustan teem, and which abound in the seas that wash her coasts, have rarely met with attention from those in authority, or even from individuals whose private tastes have led them towards the cultivation of zoological science."

Francis Day, "The Fishes of Malabar", p. vii (London: 1865).

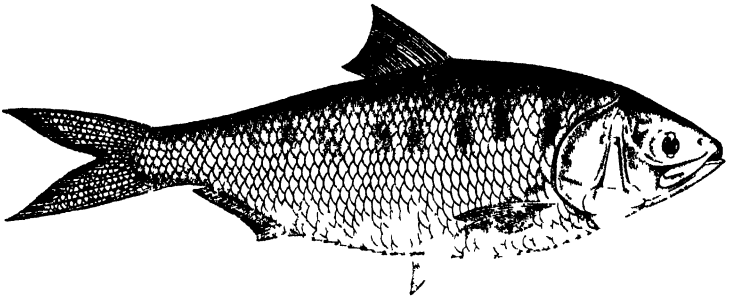
***Hilsa* fishery of Bengal**

In Bengal, it can be stated, without the least fear of contradiction, that *Hilsa* is undoubtedly the most important edible fish, whether from the point of view of the numbers caught or in view of the esteem in which it is held by the fish-eating population of the province. Although the *Hilsa* season proper lasts only for a few months during the rains the oily nature and delicious flavour of the fish, in spite of the numerous little bones which it contains, make it a most acceptable article of diet for the rich and the poor alike. Though Carp, such as Rohu, Catla, Mrigal, Calbaus, Bata, etc., are perhaps collectively of greater economic importance, no single species can claim to have the same fishery value for this province as *Hilsa*. It is essentially a marine fish of the Herring family; and, in view of its periodic ascent into the fresh waters, is known as the Indian Shad. The species, as at present understood, is known from the Persian Gulf, where it ascends into the Tigris River; from the Coast of Sind, where it is known as *Pulla* and forms an important fishery in the Indus River, and the Bay of Bengal, whence it ascends into all the principal rivers of India and Burma. I shall, however, restrict myself this evening to its wanderings in Bengal waters.

[1] Lecture delivered at the Royal Asiatic Society of Bengal on Tuesday, the 25th March 1941.

The migratory habit of the species is of the greatest value from the point of view of its fishery, for it enables us to consume this marine fish in a fresh condition very far inland; it has been caught in the Ganges System as high up as Agra and Delhi.

The life-history of this most valuable fish of the Bengal waters has until quite recently been little known, but the researches carried out by the Zoological Survey of India since 1936 have materially helped to elucidate the nature and causes of its wanderings. With a fish of such handsome appearance and delicious taste one does not need to be a zoologist to be interested in its bionomics and life-history, and it is for this reason that I have selected "Life-History and Wanderings of *Hilsa* in Bengal Waters" as the subject of my talk this evening.



Text-fig. 1.—Lateral view of *Hilsa ilisha* (Hamilton). After Day. The lateral markings on the body indicate that the figure was made from a half-grown specimen. In the young, these markings are very prominent, while in the adult they are generally absent.

Importance of Life-history Studies.

At the very outset I wish to emphasize that a thorough knowledge of the bionomics, breeding, development, rate of growth, period of maturity, etc. of any fish of economic importance is a necessary requisite for the proper exploitation, development and conservation of its fishery in all its aspects. How backward we are in this respect will be clear from Kemp's statement made in 1938 before the British Association to the effect that "throughout almost the whole of the vast stretch of the Indo-Pacific region there is scarcely a fish whose life-history is fully known and whose various stages from egg to adult can be recognized."

Earlier *Hilsa* Investigations in Bengal.

Those interested in the fisheries of Bengal are no doubt aware of the fact that in 1906, the Government of Bengal placed the late Sir K. G. Gupta on special duty to enquire into Bengal fisheries. He went into the whole question very fully and after a complete and thorough survey of the fishery resources of the province made a number of valuable recommendations in 1908. With regard to *Hilsa* he stated:

> "Very strenuous efforts must also be made to observe the reproductive functions of the *hilsa* and ascertain their spawning grounds, so that when their anadromous character has been established, hatching stations may be opened to introduce artificial propagation for replenishing our rivers."

In his general account of the species he stated:

> "the fishermen of Bengal believe that the *hilsa* does not spawn in the rivers, in proof of which it is asserted that no fry or young ones have ever been caught or seen."

In view of these weighty recommendations, the Government sent a special officer to America for studying Shad-culture. During 1909 and 1910, after his return from America, the Shad-culture specialist collected some general information relating to *Hilsa* from which he was led to conclude that spawning grounds of the species existed in the vicinity of Monghyr, Bihar. Jenkins found a single young specimen of *Hilsa*, 6 cm. long, from the market at Monghyr towards the end of September 1909 which seemed to confirm the above conclusion. Accordingly experiments were started on the artificial fertilization and hatching of eggs during several subsequent seasons but all efforts failed. Though the eggs have been fertilized and hatched, it has not been possible to rear the larvae to a fingerling stage when they could be safely planted in rivers. In 1914, in the course of his remarks on fishery questions in Bengal, Southwell surmised that:

> "The eggs of this species sink rather low in the water. Their development roughly occupies nine days. The spawning grounds are seldom, if ever, more than 600 miles from the sea. They are frequently carried along by the river current at a rate of 90 miles per day. Hence the eggs often reach the sea, or the lower part of the estuaries before they are hatched, and the development of the fry takes place there. The eggs of *hilsa* are thus not only removed from destruction by human agencies, but on account of the fact that they sink in the water, they are never carried into the paddy fields during the flood. It is undoubted I think that the maintained plentifulness of the *hilsa* year by year is due entirely to the above facts. In this case legislation appears wholly unnecessary. The eggs and fry require no protection, and any interference with the fishing of adult *hilsa* is, I think, at present undesirable."

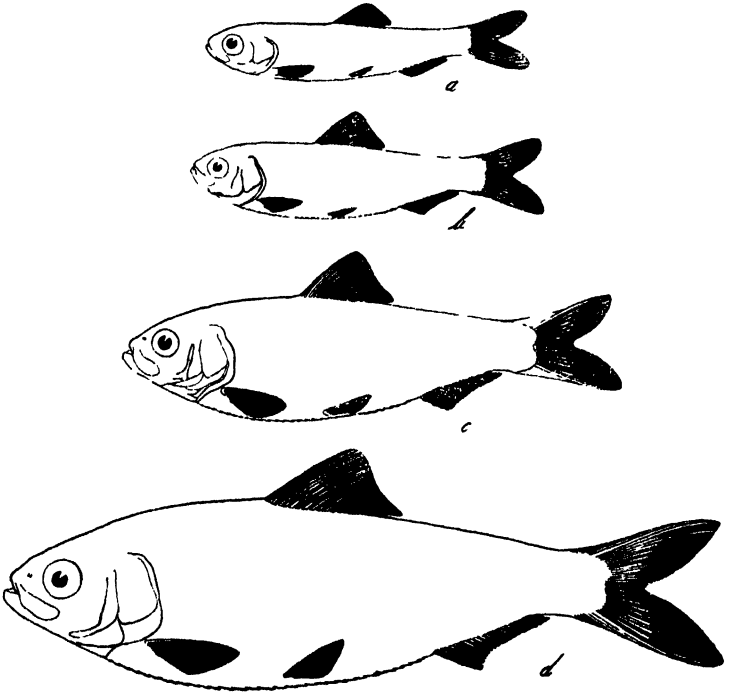
I shall show presently that the life-history of *Hilsa* is different from what was envisaged by Southwell. His time-table of the liberation and the seaward migration of the eggs of *Hilsa* is presumably based on the popular belief that the young are not found in the upper reaches of the rivers. In their general review of *Hilsa* investigations, Southwell and Prashad in 1916 recorded failure in the artificial propagation of the species and stated:

> "So far as Hilsa are concerned, successful operation in artificial propagation depend almost entirely on our understanding clearly and fully the general habits of the fish in question. The elucidation of these problems is a matter of time, for the secrets of nature are seldom unfolded to the superficial observers."

In 1919, Prashad reported on the occurrence of *Hilsa* in the rivers of Bengal and in the Gangetic Delta throughout the year and thus cast doubts on the true anadromous nature of the fish. Next year Finlow referred to the enquiries conducted regarding the young *Hilsa* or *Jatka* and the winter *Hilsa*.

The position of *Hilsa* investigations in Bengal was thus summed up by Finlow in 1933 in his note on the scheme for the reorganisation of a Fishery Department in Bengal:

> "So far attempts to locate the spawning grounds of *hilsa* have failed, and attempts at artificial fertilization have also been unsuccessful. On the other hand, the fingerling of the *hilsa* has been identified in the *Jatka*, a small fish less than 6" long, found in the Buriganga, Lakhya and Meghna rivers in Eastern Bengal in February-March. It is probable therefore that the main spawning grounds of the *hilsa* are in Eastern Bengal, and investigation to this end, particularly in the Lakhya, Buriganga, Torag and Meghna rivers, should form a definite item of the work of the Fishery Department.



Text-fig. 2.—Young of *Hilsa ilisha* (Hamilton) collected from the filter-beds of the Calcutta Corporation Waterworks, Pulta.
a. 19 mm.; *b*. 30 mm.; *c*. 42 mm.; *d*. 61 mm.

Discovery of the Spawning grounds of *Hilsa*.

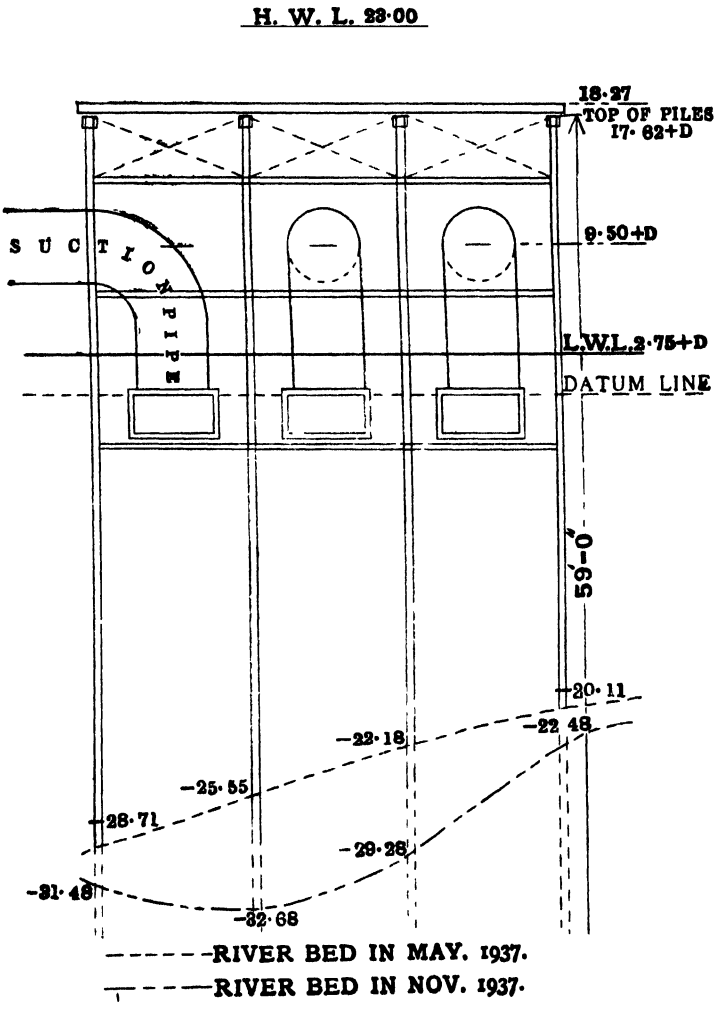
It must be remembered that with the abolition of the Fisheries Department of Bengal in 1923, the *Hilsa* investigation had also come to an end, so there was no current interest in the

problem when, in 1936, by a mere chance I was fortunate to locate the spawning grounds of the species in the river Hooghly in the neighbourhood of the Pulta Waterworks. In 1936, the Corporation of Calcutta requisitioned the services of the Zoological Survey of India to investigate the biology of the filter-beds. In the course of these investigations collections were made of the fauna and a great variety of fish was obtained. Among these were large numbers of young Herring-like forms to which no attention was paid in our preliminary determination of fishes. Fortunately, about this time the Geological Survey of India entrusted to me for study and report a small collection of fossil fish-remains from the Saline Series of the Salt Range, Punjab, among which were several incomplete specimens of small Clupeid fishes. In order to compare them with the present-day forms, the young specimens from Pulta were examined and to my very great surprise some of them appeared to be the young of *Hilsa*. Not being satisfied with my own results, I gave similar specimens to my assistants and students at the Museum and they also found them to be the young of *Hilsa*. Once the discovery was made, we applied ourselves with the meagre resources available to us in the Zoological Survey of India for fishery investigations to unravel the mystery of the life-history and wanderings of this important food-fish of the province, and it gives me pleasure to say that we have already achieved considerable success in elucidating this problem.

***Hilsa* Investigations at Pulta Waterworks and in Hooghly River.**

Here I must pause and explain the full significance of the occurrence of the young *Hilsa* in the filter-beds of the Waterworks, and have, therefore, to claim your indulgence for a short digression. At the Pulta Waterworks (Plate 5) about 90 million gallons of river water is pumped daily into the settling tanks through 5 pipes—one 36″ pipe, one 48″ pipe and three 54″ pipes. All the pipes are, however, not in commission at the same time. The mouths of the pipes (Text-fig. 3) are directed downwards. The three larger pipes are protected by an iron grating with bars one inch apart, while the other two pipes are provided with valve-like structures which prevent any large object from entering the pipes. It is thus seen that though large objects cannot be sucked into these pipes, fishes a few inches in length and less than one inch in thickness can enter the pipes. In the actual centrifugal pumps (Text-fig. 4), however, there is only a quarter inch space between the impellers and their covers so that larger objects are invariably crushed and only eggs or very young larvae can pass through intact to the settling tanks. This was tested by making several collections of the fauna from the river water soon after it had passed through the pumps; in all samples only very minute objects were obtained. This means that *Hilsa* enters the Waterworks from the river either in the egg stage or as very young larvae. Fortunately one of the *Pucca* Settling

Tanks at Pulta is an isolated one so that it can be easily charged or emptied without any interference with the working of the other units. This tank, 500 ft. long, 250 ft. broad and on an

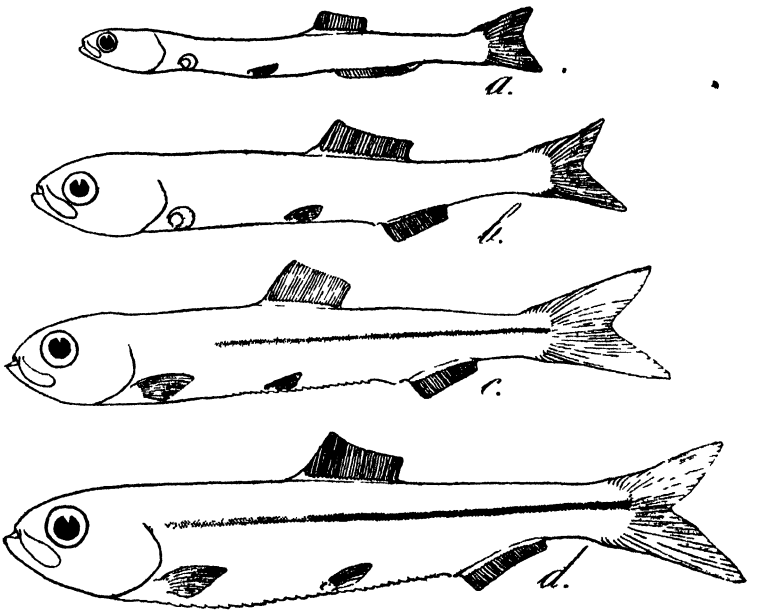


Text-fig. 3.—Section of new jetty for 54″ pipes, Calcutta Corporation Waterworks, Pulta. (Copied from *Rec. Ind. Mus.*, XL, p. 151, 1938.)

average about 8 feet deep, is occasionally charged with river water, but when the water in it becomes sufficiently settled, the upper half or more of the water depending upon its suitablity is

Text-fig. 4.—Diagrammatic sections of a Centrifugal Pump, Intake-Station, Calcutta Corporation Waterworks, Pulta.
a. Side view of section of the pump; *b*. View of a section through *xy* of *a*; A. Suction space; B. Pressure space.
An arrow indicates the direction of flow.

drawn off to the filter beds, and the tank is filled up again with river water. This process is repeated from 2 to 8 times in a month depending upon the weather conditions and the amount of suspended matter in the river water at different seasons. The *Pucca* Settling Tanks are thoroughly cleaned once a year and during one such operation on the 21st November, 1937, 900 young *Hilsa* from Tank No. 4 were measured (*vide* Table I, p. 110). From the different sizes represented in this lot, the probable rate of growth of the species was surmised. Further, taking advantage of the fact that only eggs or larval fish can pass through the centrifugal pumps to the settling tanks, the tank was almost completely dewatered once a month so that the young of the various species of fish developed from eggs or larval forms received from the river during the month were collected. It



Text-fig. 5.—Larval forms of *Hilsa ilisha* (Hamilton) collected from the Pucca Settling Tank No. 4, Calcutta Corporation Waterworks, Pulta. ×4½. After Nair. (Copied from *Rec. Ind. Mus.*, XLI, p. 411, 1939.).
a. 14 mm.; *b.* 18 mm.; *c.* 20 mm.; *d.* 22 mm.
Mr. K. K. Nair's figures of the larval forms of *Hilsa* show varying number of rays in the dorsal and anal fins, but he has informed me that the figures in this respect are diagrammatic and, therefore, no significance need be attached to this point in considering their identity.

was, however, too costly to dewater the tank completely and to clean it up properly every month, so some young forms received

in the tank during earlier months usually got mixed up with the stock that came in later, but they could be readily eliminated on account of their larger size. The material thus collected for one year (first collection was made on December 28, 1937), has furnished valuable data regarding the season of breeding and the probable rate of growth of a number of species found in the river Hooghly. So far as *Hilsa* is concerned, these observations have conclusively shown that *Hilsa* breeds in the Hooghly throughout the year though the peak period of breeding is during the rainy months of July and August. Observations on the month to month growth of the species have shown that specimens 10 months or a year old are just about a foot in length, and that the fish attains a marketable size in a few months' time. The rate of growth is more rapid during the hot months, and it has been found that during July-August the young of *Hilsa* attain a size of about 2 inches in the first month and thereafter the size increases at the rate of about an inch per month with the exception of the winter months when the growth is somewhat retarded. It may here be stated that similar results had also been obtained by the Madras Fisheries Department regarding the growth of the species in certain South Indian rivers.

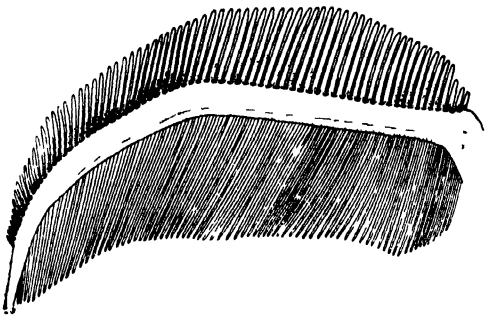
In the *Pucca* Settling Tanks, facilities for the movements of bottom or mid-water fishes, like the *Hilsa*, are restricted and the thorough cleaning of the tanks every year does not permit of such species to grow beyond one year. In another series of five large *Kachha* Settling Tanks, however, the fish can move about freely and some of them can live up to their maximum age. Specimens of 18 inches and over have been obtained from these tanks and some of them were fully mature as the milt and eggs streamed out when they were caught. Whether *Hilsa* is capable of breeding in confined waters or not, we have not been able to ascertain. It is certain, however, that the fish is not unsuitable for tank culture, although it must be stated that in freshwater tanks the fish loses much of its flavour and taste [1]. However, experiments may be started in the brackish water areas of the Sunderbans for the culture of this species, for, as I shall presently show, the young of *Hilsa* are plentiful in those waters and no expensive hatcheries are needed for this purpose.

Another important advance in our knowledge of the life-history of *Hilsa* was made near Pulta. From the collection of river fishes made at Nawabgunge at different seasons some light was thrown on the movements of the young *Hilsa* in the river

[1] Those who have had occasion to taste the flesh of *Hilsa* from the rivers of Bengal and also from those of Bihar and the U.P. have told me that the up-country *Hilsa* is a very poor fish. On account of the large number of small bones it rarely finds favour with the better class of people in the U.P.

Hooghly. We found that large quantities of very young *Hilsa*, some as small as 35 to a tola in weight, are caught in the Hooghly during November to February; the size of the specimens obtained at Nawabgunge, however, increased month after month (*vide* Table II, p. 111) showing thereby that the progeny of the individuals that spawned higher up was passing down to the sea.

At Pulta we also investigated the food of the species from the young to the adult stage and found it feeding on planktonic



Text-fig. 6. – Lower half of first left gill-arch of a young specimen of *Hilsa ilisha* (Hamilton). ×2½. (Copied from *Rec. Ind. Mus.*, XL, p. 155, 1938).

The actual number of gill-rakers on this portion of the gill-arch was 156, but 95 could be shown in the drawing.

organisms. A study of its branchial arches showed that they are definitely adapted for straining microscopic life; its gill-rakers are setose, long, slender and close-set, and act like a sieve.

Hilsa Investigations in Eastern Bengal, etc.

Having obtained some information regarding the life-history of *Hilsa* from our studies at Pulta and at Nawabgunge on the river Hooghly, we extended our observations to other rivers of Bengal and those of the neighbouring provinces. Our first attempt was to elucidate the fishery of the *Jatka* fish of Eastern Bengal to which Finlow had referred in his reports mentioned above. In February 1939, Mr. M. N. Datta of the Zoological Survey of India visited Barisal, Patuakhali, Galachipa, Chandpur, Narayangunge and Goalundo, but he was not able to collect any definite information regarding *Jatka*. However, among the specimens collected by him at various places we found young *Hilsa* (*vide* Table III, p. 111) from 1 to 5 inches in length which clearly showed that, as in the River Hooghly, the fish breeds in the rivers of Eastern Bengal throughout the year. Mr. Datta found extensive fishing for young *Hilsa*, 7 to 11 inches in length, at Goalundo, Narayangunge and Chandpur. In 1940, through the kind interest of the District

authorities, several consignments of *Jatka* were received from Lakshmipur, Narayangunge and Dacca. Our detailed studies on the taxonomy, size and food of these specimens have definitely established that *Jatka* represent the young of *Hilsa* 2 to 5 months old, that the migration of *Jatka* from the estuaries into fresh-waters is for feeding purposes, and that during the *Jatka*-phase, the fishery of which lasts from February to April, the *Hilsa* feeds and grows until April-May when the feeding stops and the growth is inhibited. It is remarkable that the *Jatka* disappears from the rivers as suddenly in April-May as it reappears in them in February-March. The significance of *Jatka* in the fishery of *Hilsa* will be discussed later.

Through the kindness of Professor D. R. Bhattacharya we have obtained young, half-grown, and adult specimens of *Hilsa* from Allahabad (*vide* Table IV, p. 111), and through the courtesy of Mr. Stanley Howard a very young specimen from a tributary of the Mahanadi River in the Patna State (*Statesman*, Calcutta, 18th October, 1940). The Madras Fisheries Department found the young of *Hilsa* in the rivers of Madras and made valuable observations on the rate of growth and life-history of the species. It has now been definitely established that the swarming of the mature *Hilsa* into the rivers during the flood season is mainly for spawning purposes, but a number of young individuals also ascend and these travel far inland before they become sexually mature. Thus we get *Hilsa* breeding throughout its range both in the tidal waters and in the middle reaches of the large rivers. Though a number of specimens of *Hilsa* can always be found in the rivers, the floods and the sexual maturity of the migrants seem to induce the swarming *Hilsa* in the sea to undertake the upward journey into the rivers.

Marine Life of *Hilsa*.

Having located the spawning grounds of *Hilsa* and its mode of life in rivers, our next attempt was to get some idea of its wanderings in the sea. Here again fortune favoured the Zoological Survey of India. In February-March 1939, a party of the Department in the course of its investigations on the fauna of the Balasore Coast at Chandipore found extensive catches of *Hilsa* from the sea in *Ber* fishery. Later it was found that O'Malley in the Gazetteer for Balasore District had already recorded that extensive *Hilsa* fishing is carried out in the sea along the coast. He observed:

> "The fishermen are particularly keen in their pursuit of the *hilsa*, and a flotilla of sea-going craft will sometimes drift along together for days, awaiting the approach of a shoal of that fish. When the shoal arrives, they at once fill their boats, steer straight for shore, and convert their haul into *sukhua* or sun-dried fragments of fish—a favourite relish with the Oriyas."

These observations led us to consult all earlier works on *Hilsa* very carefully and we were rewarded by finding several

references to *Hilsa* in the sea. Further, it became clear that along the coasts of Bengal and Orissa and in the estuaries young *Hilsa* about 7 to 10 inches in length were fished extensively during the cold months. We arranged to get samples of *Hilsa* from Chandipore every month from which our tentative conclusions are that *Hilsa* in all stages of growth are found in the sea all along the foreshore in the shallow waters of the Bay of Bengal, that most of the specimens caught in November are less than one year old, and that the fish feeds and continues to grow in the sea except during November and February and possibly during May-June also.

The earlier records of the occurrence of *Hilsa* in the sea and the results of the enquiries made by us from the officers in charge of the Pilot Vessels stationed not very far from the mouth of the river Hooghly (Plate 6) leave no doubt that after leaving the rivers the fish do not go far into the sea but move about in shoals in the estuaries and the foreshore. The fish lives in shallow waters and has not yet been recorded from waters more than a few fathoms deep.

Though our observations are yet inadequate and inconclusive for any fishery forecasts, we can confidently claim that an advance has been made in our knowledge of the life-history and wanderings of *Hilsa*. For instance, we definitely know that the spawning grounds of *Hilsa* are in our rivers and that the young of one to three inches in length are caught in the rivers in basketfuls during the months of November to February to be sold at the rate of 6 pice per seer. Again during the cold weather, shoals of this fish about 7 to 9 inches long are caught in the estuaries and along the foreshore. In February-March there is an extensive fishery of *Jatka* in the rivers of East Bengal, and then during the monsoon floods mature fish swarm up the rivers and yield us our most valuable *Hilsa* fishery. In the circumstances detailed above it is a wonder why the fish has not been totally exterminated so far, for we have devised extensive fisheries of the species in all stages of its growth and in all places where it wanders from season to season. I shall now attempt to discuss the causes that have saved this species from total destruction.

Close Period for *Hilsa* Fishery.

In the olden days, the Hindus of Bengal did not eat *Hilsa* from the last day of the Durga Puja, usually at the end of September or at the beginning of October, to the Sri-panchmi day, at the end of January or the beginning of February, or in other words a close season of about three and a half months was observed. This is the period when the main swarms of *Hilsa*, after spawning in the rivers, go back to the sea to recuperate and fatten for the next spawning season and their young move down to the sea in large numbers. During these phases the fish is of poor quality and hardly worth eating. But owing to the

pressure of increasing population on the food resources of the country and to the so-called advanced modern education, the people now ignore this injunction as a piece of superstition. In all important fisheries, a close season is observed all over the world and there is no reason why the old practice that has probably helped to preserve the fishery to a certain extent, may not be revived. Though during the season all possible means are adopted by the fishermen to entrap swarms of *Hilsa*, many still escape to propagate the race. Even one adult pair, under suitable conditions, can produce tens of thousands of young ones. As the eggs sink to the bottom and the fry start their seaward journey soon after hatching they escape destruction and reach the sea when the rivers are still in floods. Thus natural protection is afforded to the fry during rains. As pointed out already, *Hilsa* fry are caught in the rivers when the waters fall low in November-December and it becomes possible to use fine-meshed nets at the bottom. During nor'westers also the young of *Hilsa* are left alone because the weather conditions are not favourable for using fixed bottom nets. Nature has thus made some provision for the protection of the young, but how far the greed of man will allow it to remain effective, it is difficult to say. In the light of the above remarks, it is imperative, however, to consider the question of devising protective measures for the conservation and proper exploitation of this important fishery.

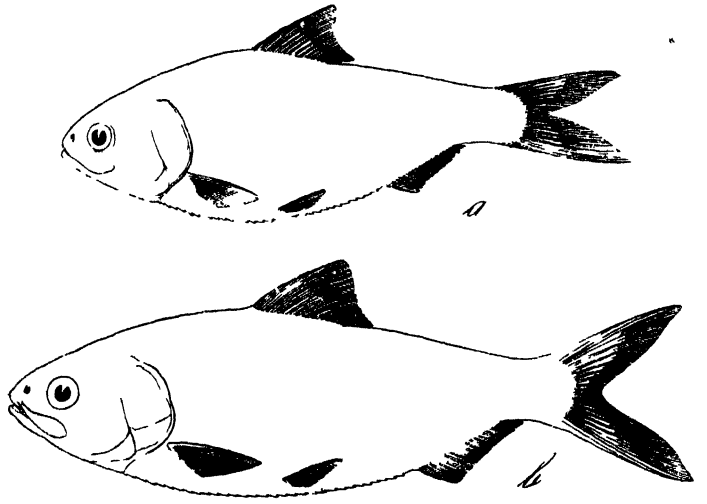
Natural Protection for Fry.

In his recommendations, the late Sir K. G. Gupta thought of this eventuality and suggested that hatching stations may be opened for the artificial propagation of the species with a view to replenish the depleted rivers of Bengal. In this connection it must be remembered that, besides the question of heavy cost, the greatest output of a series of hatcheries would be but a trivial fraction of the output from a relatively small number of natural spawners. So true is this that in many advanced countries, in trying to maintain salmon in streams, the authorities have stopped hatchery work and are concentrating on helping the spawning fish to get on to the natural spawning beds. From what I have seen and learnt of the *Hilsa* fishery, I am definitely of the opinion that even now there are plenty of fry, but the great problem is to devise a way to protect the young *Hilsa* so that a due proportion may reach maturity and spawn. I have shown that at present very young *Hilsa* of about 1 to 3 inches in length are caught in basket-loads during November to February, young of about 6 inches in length, known as *Jatka*, are caught in millions in the rivers of Eastern Bengal during February-March-April and throughout the cold season young fish of 7 to 9 inches are caught in boat-loads in the estuaries and along the foreshore. The fishery of young *Hilsa* at all these

***Hilsa* Hatcheries not required.**

stages leads to the depletion of the natural stock. With the increasing demand for fish, there will be a corresponding activity in catching fish of all sizes. However, in legislating for regulating the relatively unproductive fishery of the young, some alternate mode of subsistence will have to be found for the fishermen, otherwise, it may mean great hardship to those poor people. In view of the abundance of young *Hilsa* in Bengal waters, there is hardly any necessity for establishing *Hilsa* hatcheries. All the same the question of the *Hilsa* fishery in Bengal is of such vital importance that it requires very thorough investigation before any remedial measures can be suggested. For instance, in reviewing our *Hilsa* investigations, European and American experts have surmised, on the analogy of Herring-fisheries in European waters, that there may be different races of *Hilsa* which breed under different environmental conditions. Our

Likelihood of several Races of *Hilsa*.



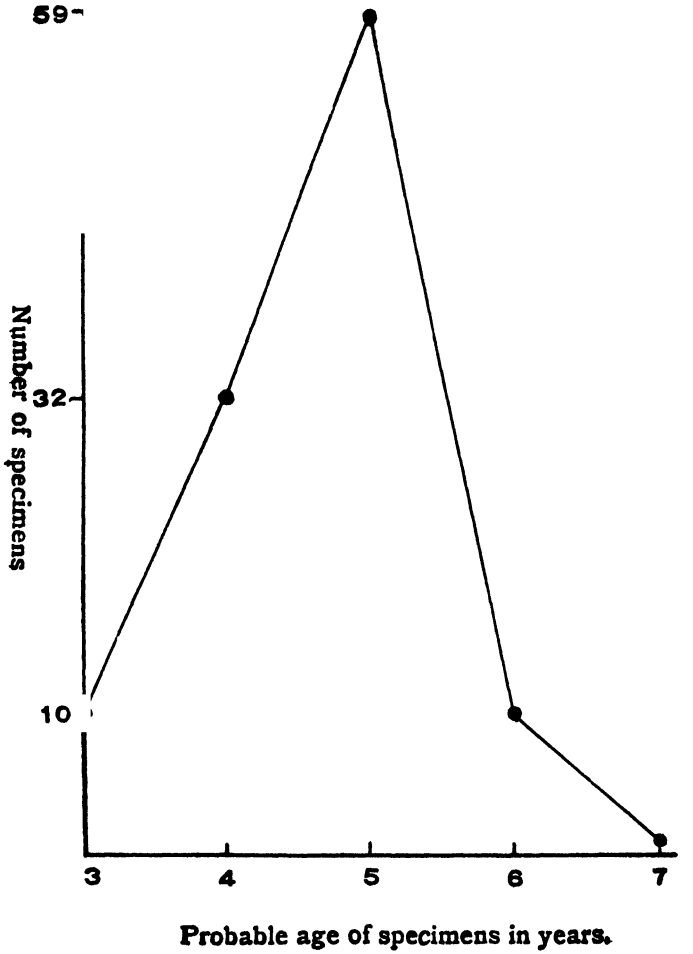
Text-fig. 7.—Two forms of *Hilsa ilisha* (Hamilton) as judged by the depth of the body and the form and size of the head.

a. East Bengal form. Length 124 mm.; *b*. Hooghly river form from Pulta. Length 150 mm.

investigations also indicate the possibility of our having several races or varieties of *Hilsa* in Indian waters, and though we are making every possible effort to elucidate this point, with the limited means at our disposal, it will take considerable time to get together the necessary material and to make the requisite biological observations. The *Hilsa* fishery is really a very vast problem.

Fluctuations in *Hilsa* Fishery. Five-year Cycle.

Sir K. G. Gupta, in the course of his enquiries, received complaints from all directions that the supply of *Hilsa* was on the decline. But all of us are aware that *Hilsa* was most abundant in 1934, the year of the Bihar



Text-fig. 8.—Graphic representation of the probable age of 112 specimens of *Hilsa ilisha* (Hamilton) imported into Calcutta from Goalundo during June-July, 1939. (Copied from *Rec. Ind. Mus.*, XLII, p. 48, 1940).

earthquake, and in 1939. It has been suggested that there is a five year cycle in the fishery of this species. From the authorities

of the A. B. Railway at Chandpur, I have been able to obtain valuable data (*vide* Table V, p. 112) regarding the booking of *Hilsa* fish to principal stations on the A. B. Railway for the years 1937, 1938, 1939 and 1940. I was also informed that the season for *Hilsa* generally starts from April and continues up to October. The figures in the table show great annual fluctuation in the fishery and also fluctuations from month to month. If future observations bear out our assumption regarding the five-year cycle in the fishery of *Hilsa*, it will be the duty of persons interested in the welfare of the masses to see that the catches of the fishermen during such periods are properly preserved so that they can be utilized during the lean years of the fishery. In 1939, the *Hilsa* fish was so plentiful in Bengal that tons of fish were allowed to go waste in Eastern Bengal, for there was no one to purchase them. If proper arrangements [1] had been made in the form of having a floating cannery, which could be moved from place to place, the problem of finding a considerable quantity of canned fish or fish oil would not trouble anybody now.

In Europe and America, it has now been ascertained definitely that "Annual fluctuations in the abundance of a fish may be very great. One year may be exceptionally favourable, with production far above normal, to be followed perhaps by several years of scarcity; and it is not uncommon to find that fish belonging to one year class are fifty times as numerous as those of another. These great fluctuations, which are the foundation on which fishery prediction is based, are for the most part to be attributed to events which happened in the early months of the fish's life; and when we consider the manifold perils, meteorological, physico-chemical and biological, to which the eggs and larvae of a marine animal are subject, it is little wonder that there may be such great differences from one year to another, nor is it a matter for surprise that the precise reasons for good and bad spawning seasons are as yet unknown." (S. W. Kemp, Presidential Address. Zoology Section. Brit. Ass. Adv. Sci. 1938). In the case of *Hilsa*, though considerable advance has been made in our knowledge of its bionomics and life-history, a great deal still remains to be done by a band of expert scientists to put its fishery on a scientific basis. It is for the elucidation of these and similar other problems that the establishment of a well-equipped and suitably staffed fishery department in this province is absolutely essential. The economic value of *Hilsa* to this province is so great that its fishery alone may form the subject for investigation by a commission.

Scientific Exploitation of the Fishery urged.

[1] Fisheries in India suffer mostly for two reasons—lack of transport facilities and the primitive methods adopted by fishermen in preserving their catches. Fortunately we have still extensive fisheries which can yield valuable food supply, if properly exploited.

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TABLE 1.

Table of Measurements of 900 Young Hilsa *collected from the* Pucca *Settling Tank No. 4 on 21st November 1937, arranged in 10 mm. Difference groups.*

Number of specimens.	Measurements in millimetres.
1	57
7	80–89
72	90–99
56	100–109
52	110–119
32	120–129
97	130–139
273	140–149
220	150–159
74	160–169
14	170–179
2	180–189

TABLE II.

Length in mm. of young Hilsa *collected at Nawabgunge.*

Date of collection of samples.	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99
30th October, 1938 ..	204	153	3	..	..	..	..	..
13th to 15th November, 1938 ..	5	42	78	4	2	..	..	..
27th February and 1st March, 1939	..	..	8	45	22	3	3	1

TABLE III.

Young Hilsa *from East Bengal collected in February* 1939.

Length in millimetres.	Number of specimens collected at			
	Gazalia (River).	Galachipa (River).	Patuakhali (Market).	Narayangunge (Market).
30–39	..	..	3	..
40–49	..	..	20	..
50–59	..	1	30	..
60–69 ..	..	..	29	6
70–79	..	..	33	3
80–89 . ..	1	..	6	2
90–99 .. .	.	1	2	
100–109	4	3	4	
110–119 . ..	10	7	18	
120–129 . ..	2	11	17	.
130–139	1	2	4	.

TABLE IV.

Young Hilsa *collected at Allahabad by Professor D. R. Bhattacharya on or about the 20th June*, 1940.

Standard length in millimetres.	Number of specimens.
53	1
58	1
59	1
60	1
61	1
62	2
64	3
65	1
66	1
69	1
74	1

TABLE V.

Figures in maunds of Hilsa *exported from Chandpur from April to October during 1937, 1938, 1939 and 1940.*

Name of month	1937.	1938.	1939.	1940.
April	954	198	1,359	1,288
May . ..	1,364	265	2,517	1,331
June .. .	3,300	879	8,544	4,401
July .. .	2,697	1,709	5,268	4,137
August ..	985	1,380	2,003	1,630
September ..	1,708	1,936	3,675	5,117
October .	1,232	1,633	2,786	4,230
TOTAL .	12,240	8,000	26,152	22,134

EXPLANATION OF PLATES.

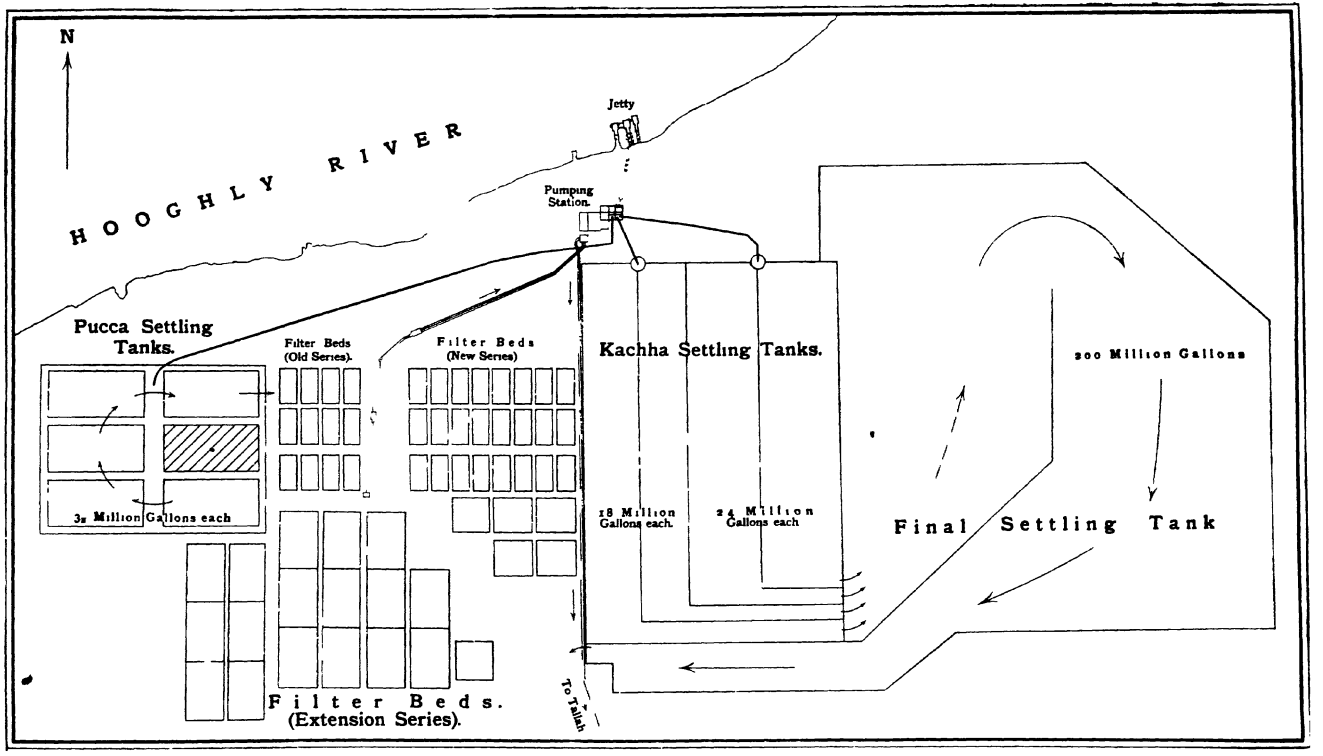
Plate 5.

Site plan of Calcutta Corporation Waterworks, Pulta.

Plate 6.

A map of Sandheads and the Balasore Coast. The five, ten and twenty fathom depth zones are indicated by different types of hatched lines. (Copied from *Rec. Ind. Mus.* XLII, pl. ix, 1940).

From the abundance of *Hilsa* shoals in the shallow flats close to the river mouths and their neighbourhood on the Bengal and Balasore Coasts and their probable absence from the area round Pilots Ridge it is surmised that this species in its seaward migration does not go far out into the sea.



SITE PLAN OF PULTA WATER WORKS.

PLATE 5.

SANDHEADS
AND
BALASORE COAST
24 PARGANAS
MATLA RIVER
RIVER HUGLY
Sagar Island
Eastern Channel
Western Channel
3 Fathom line
5 Fathom line
10 Fathom line
Pilots Ridge
MIDNAPORE
SUBARNAREKHA RIVER
BALASORE
CHANDIPORE
BAY
OF
BENGAL
DHAMRA RIVER

Journal Royal Asiatic Society of Bengal. Science.

Volume VI, 1940.

ARTICLE No. 11.

A Psychological Study of Arithmetical Ability with Reference to the Students of Secondary Schools.

By N. C. CHATTERJEE.

(*Communicated by Dr. G. Bose.*)

INTRODUCTION.

This is a report of an investigation in the field of arithmetical abilities of the students of Secondary Schools. The work extended over a period of two years, 1939 and 1940, and samples of High School students in Bihar and Bengal were tested in arithmetic under my close personal supervision.

The idea was to effect, by statistical analysis—

(*a*) a standardized objective test in 'reasoning' arithmetic on grade-norm basis, suitable for the students of Secondary Schools,

(*b*) a psychological analysis of the students' responses to the questions of the test and their educational implications, and

(*c*) a comparative study of the arithmetical abilities of students in Bihar and Bengal.

The first of the aforesaid topics was already published in a non-technical form and was, in a way, supplementary to and a continuation of a similar work undertaken by me some time back, which resulted in a standardized objective test in 'mechanical' arithmetic for the High School students on grade-norm basis and which was published in the Indian Journal of Education, September, 1939.

For the purpose of the present investigation I have drawn my inspiration and guidance from works of Prof. Thorndike, Dr. Ballard, C. W. Stone, S. A. Courtis, Prof. W. S. Monroe and various interesting contributions concerning the nature of arithmetical ability that have appeared from time to time in the British Journal of Educational Psychology. To this list I should add, most humbly, my own experience as a teacher concerned with school mathematics of no less than 22 years' standing.

Standardization of the Test.

Arithmetic, as is generally taught in schools has two parts, namely, the 'tool' and 'problem' parts. The former deals with such topics as the four simple and compound rules, reduction, practice, fraction, decimals, square-root, L.C.M., G.C.M., average, etc., that require only mechanical working out

of sums, while the latter deals with all sorts of arithmetical problems demanding the exercise of reasoning. This, by no means, however, implies that the two parts are mutually exclusive.

When a child works out a problem sum, his mental process involves, in the first place, his powers of comprehension, analysis, synthesis, assimilation, judgment, etc., all of which may be put under the term, reasoning, as is popularly conceived. In the second place, this conscious process of reasoning brings into play a train of habit-bonds, more or less automatic, which the children must have built up earlier in course of their drilling in tool arithmetic. Thus, arithmetical ability that functions through problem sums involves children's power of reasoning as well as their skill in mechanical computation.

My present investigation being a study of arithmetical abilities through problem sums, I made, at the outset, a tentative selection of about a hundred such sums from all topics of arithmetic that are taught to the four top classes of a High School. Utmost care was taken to see that the problems were as easy as possible. Six graduates were then engaged, one at a time, in working out these sums at their normal speed, and in every case the time taken for each sum was carefully reckoned in seconds by means of a stop-watch. The average number of seconds thus required for each sum was next calculated and those sums that took comparatively less time than others and also were found fairly representative of the whole 'problem' part of arithmetic were retained and the rest discarded. Thus were left thirty problem sums as listed below:—

ARITHMETICAL REASONING.

1. Two-thirds of a class consist of 20 boys. How many boys are there in the class?
2. Find the cost of 12 chairs at Rs.5-8 per pair.
3. A carpet 20 ft. by 15 ft. cost £10. What was the cost per square yard?
4. Ram is as old as Mohan; Mohan is twice as old as Rahim; Rahim is as old as Hari. If Hari is 5 years old, how old is Ram?
5. I want equal numbers of stamp and post card for Rs.1-5. If a stamp cost one anna and a post card 9 pies, what will be the number of each?
6. How many men can do a piece of work in 12 hours which 4 men can do in 18 hours.?
7. A man takes 20 minutes to walk from his house to the station. His son also takes 20 minutes. How long will it take them if they both walk together?
8. What is the greatest number that will divide 64 and 76, and leave a remainder 4 in each case?
9. The area of the floor of a room is 196 square feet. What is the sum of its four sides?
10. If mango sells at the rate of Rs.3-2 per 100, how many can I buy for 7as.?
11. The distance round the wheel of a motor-car is 3 ft. 6 in. How many times does the wheel go round in travelling 140 yd.?

12. Find two numbers whose sum is 19 and whose difference is 5.
13. The area of a field twice as long as it is broad is 200 sq. yd. Find its sides.
14. How many times can I subtract 3 from 73?
15. What is the length of a stick which I can cut up into 8 pieces, each 6 in. long and have 4 in. left over?
16. A man aged 35 years is 7 times as old as his son; how many times as old as his son will he be 25 years hence?
17. At what rate per cent, simple interest, would Rs.10 amount to Rs.11 in 4 years?
18. Rs.9-11 is made up of equal numbers of Rupees, eight-anna, four-anna, two-anna and one-anna coins. Find the number of each.
19. I buy some articles for Rs.40; what must I sell them for, so as to gain 20%?
20. If $\frac{3}{5}$ of a piece of cloth cost Rs.3-6, what is the cost of the whole piece?
21. After spending half of my money and then half of the remainder I had 2 annas left. How much had I at first?
22. Divide Rs.30 between A and B so that their shares may be proportional to 6 and 4.
23. What is the least number which must be subtracted from 45 to make it exactly divisible by 7?
24. What two whole numbers multiplied together make 11?
25. There are two numbers one of which is greater than the other by 4. When multiplied together they make 165. What is the smaller one?
26. If telegraph poles stand 50 yd. apart in a straight row, what is the distance from the first to the eighth?
27. 5% of A's income is the same as 15% of B's. A's income is Rs.300 a year. What is B's?
28. A brick weighs 7 lb. and half its own weight. What is the weight of the brick?
29. If a man's salary is Rs.80 a month and he spends Rs.56 a month, how long will it take him to save Rs.600?
30. If 2 pencils cost 5 pice, how many pencils can you buy for 50 pice?

The average time taken for doing each sum being not much, each was given 1 mark as its weight. This does not mean, however, as will be presently seen, that the difficulty values of these problems were the same for the school pupils for whom the test was standardized.

The test was now printed and administered to 73 graduates and 1,520 High School students at Patna during the months of September and October, 1939, under my personal supervision, and uniform conditions were observed throughout. Eight schools of different types were selected for the test in order that the samples might be fairly representative of the 'population'. Exactly half an hour was given to each group of subjects to answer the questions and in the case of Class VIII these were translated into Hindustani and Bengali, which were introduced as media of instructions from 1939, beginning with that class. The students were asked to work out the sums 'in their head' or on scrap papers if they so liked and were told to put down their answers at the end of the questions. Every step was taken to secure normal and independent responses of the subjects, who were strictly prevented from using any unfair means whatsoever.

The marking of the answers was now a simple affair. The questions whose answers were correct were tick-marked and counted, and then the totals were put down at the bottom of the question papers. The services of some pupil teachers of the Patna Training College were requisitioned at this stage of work. After the students' responses were thus measured, their 'point-scores' were dealt with statistically, class by class, with the result as shown by Table 1 below:—

TABLE 1 (*Patna*).

	Q_1	Median	Q_3	Mean	σ	Skewness
Graduates ..	19·6	23·6	26·3	22·3	5·4	—·72
Class XI ..	12·5	16·6	21	16·8	5·7	+·10
Class X .	9·5	13·7	17·1	13·6	5·5	—·05
Class IX	7·3	10·3	14·8	11·2	5·1	+·53
Class VIII ..	6·3	9·7	13·3	10	5·0	+·18
Classes IX and VIII combined .	6·8	10	14	10·54	5·1	+·32

N.B.—Q_1 = First Quartile.
Q_3 = Third Quartile.
σ (sigma) = Standard Deviation.

Next year the test was translated and printed in Bengali and administered to 884 boys in three High Schools selected at random, in Calcutta, during the month of May. Exactly the same process was gone through in regard to the collection of data, measurement of scores, tabulation of figures, etc., as was done in the case of Patna students. The corresponding table is given on the next page.

The norms or pass standards for the test were now easily deduced from the above tables by making a compromise between the mean and the median for each class and by leaving out the decimals. Thus the norms are as follows:—

Patna classes	XI	X	IX	VIII
Calcutta classes	X	IX	VIII	VII
Norms	16	13	10	9

This means that a student of average merit should correctly answer 16 questions if he belongs to the topmost class, 13

TABLE 2 (*Calcutta*).

	Q_1	Median	Q_3	Mean	σ	Skewness
Class X ..	12	16·2	22·3	16·1	5·5	−·05
Class IX ..	9·3	13·1	17·3	13·5	5·3	+·22
Class VIII ..	6·3	9·2	12	9·6	4·3	+·28
Class VII ..	5·5	8·7	11·8	9·5	5·6	+·43
Classes VIII and VII combined ..	5·9	9	11·9	9·57	5·0	+·34

questions, if he belongs to the next lower class and so on, provided that all the conditions of the test including the time of the year are strictly observed. It may be noted here that a psychological test of achievement to be really scientific and effective should be standardized on the age-norm rather than on the grade-norm basis as the present test is. But as the information about the students' chronological ages required for the age-norm basis was not thought to be accurate enough for a strictly scientific enquiry I had to confine myself to the calculation of the grade-norms alone.

Before the test is considered as standardized for the Secondary Schools of both Bihar and Bengal we must show that it satisfies a number of statistical criteria. A good test is judged mainly from its validity, reliability, objectivity and ease of administration and scoring.

The two criteria, reliability and validity, refer to different aspects of what is essentially the same thing, namely, test efficiency. But the test efficiency is impossible of attainment unless the samples with which the test is standardized are representative or adequate in character. So, let us first see if our samples are really representative.

One of the simplest tests of the representativeness of a sample consists in drawing from the 'population' more than one groups of fairly large size. If the measures of central tendency, variability, etc, calculated from these groups are of nearly the same magnitude, we may be reasonably assured that our sample is representative. A glance at Tables 1 and 2 clearly indicates that (i) the quartile, median and mean measures of the arithmetical abilities of the two groups of students tend to be equal to one another, class by class, (ii) these measures, again, increase in the same manner from the lowest to the highest class, (iii) the

standard deviations from the mean tend to remain constant, and (iv) the skewness of the distributions is insignificant in the higher classes but is quite prominent in the lower.

When we scrutinize the figures in the first four columns of the tables more closely, we find that the measures for the Calcutta students fall slightly short of those for the Patna students in the higher forms and markedly short in the lower forms. The reasons for this general deviation will be quite clear when we remember that the test was applied to the Calcutta Schools four or five months earlier in the Session than in the case of Patna, and that only three schools were tested in Calcutta as against eight at Patna. I am sure that the difference would not have arisen had the conditions regarding the time of test and the number of schools remained the same at both the places. If, however, we allow to the Calcutta figures ·5 to 1 marks for this emergency, the measures in question will be exactly the same in the higher classes and almost the same in the lower. Thus we see that the two groups of samples tell almost the same story and so we may safely say that they are representative of the 'population' from which they were drawn.

The validity of a test or other measuring instrument is determined *directly*, where possible, by finding the correlation between the test and some independent criterion. Such a criterion must be a highly objective measure in terms of which the value of the test is estimated. But the difficulty is that we are not able to secure independent measures of abilities that are recognized as highly accurate. We are, therefore, compelled to study the validity of most tests by methods which are *indirect*.

One of the indirect methods of validating a test is to rely upon the independent opinions of competent judges, and still another is to see if the statistical results agree with our expectations. Both these methods were employed to validate our present test.

The teachers in charge of mathematics in one of the schools at Patna, immediately after it was tested by us, were asked to supply me with twelve names of boys in each class ranked in order of merit such that four of them would be the best, four mediocre and four worst, in their independent opinions. These groups of boys were next ranked on the basis of my test and the correlation co-efficients were calculated by means of the method of 'Rank Differences' with the result that these were found to range from ·78 to ·92. The validity, therefore, is highly satisfactory on this count.

Next let us consider how far the findings of our test tally with expectations. In regard to a test in which the exercises are of varying difficulty values as they will appear to be in our present test, the test-makers have made two important assumptions (W. S. Monroe's Theory of Educational Measurements, pages 92, 145-46). First it is assumed that when an unselected

group of pupils, such as those belonging to a given school grade, is distributed according to a given ability, a 'normal distribution' is secured. The second assumption is that the variability of this distribution remains the same for successive school grades. Prof. Monroe says that these assumptions appear to be approximately in agreement with available data. A corollary to the first assumption, which too has been found to agree with facts, is that if the test of this nature is applied under the same conditions to groups of subjects of varying degrees of ability to be measured, the distribution will be negatively skewed or 'loaded' at the high score end in the case of the advanced group, positively skewed or loaded at the low score end in the case of subjects of lower ability and normal for the rest. The findings of our test tell exactly the same story. At Patna, the test was applied to 73 graduates and the resulting distribution was found to be negatively skewed or heaped at the high score end. The combined distributions for the two top classes of both Patna and Calcutta students or those for them singly are found to be almost exactly normal or symmetrical; while the corresponding distributions for the two lower classes are clearly piled towards the low score end.

The first of the above facts will be sufficiently clear to the reader from Table 1, where the skewness calculated from the graduates' group is shown, and it is as high as −·72. The other two facts will be vivid to the eye from Table 3 and also from the three graphs that follow, showing the relationship between the 'obtained' distributions and the 'best fitting' normal curves.

TABLE 3.

Calcutta Classes	Q_1	Median	Q_3	Mean	σ	Skewness
X and IX ..	10·4	14·7	18·8	14·86	5·5	+·09
VIII and VII	5·9	9	11·9	9·57	5·0	+·34
Patna Classes						
XI and X ..	10·7	15	18·9	15·07	5·78	−·03
IX and VIII	6·8	10	14	10·54	5·1	+·32

In each of the following figures the obtained frequency distribution has been plotted in histogram and the 'ideal' normal curve has been drawn on the same axis of reference and of the same area,

mean and σ (sigma), in order to bring out clearly the relationship between the two.

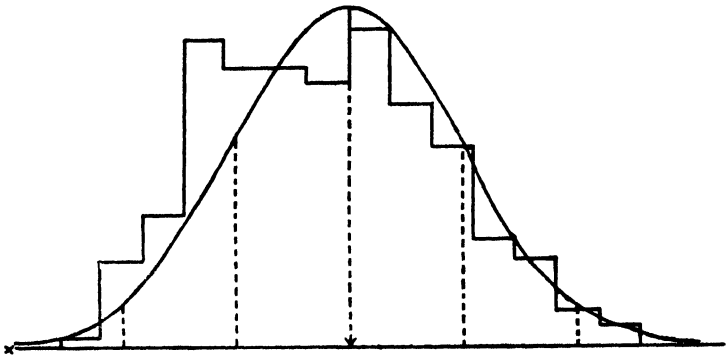


FIG. 1.

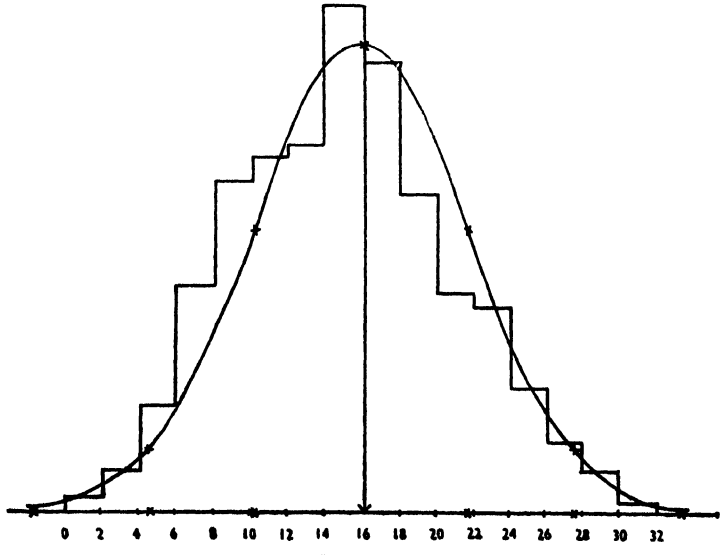


FIG. 2.

The χ^2 (chi-square) test being much too laborious, I have used this short-cut device to judge the 'goodness of fit by eye' and I think, this is quite useful for our purpose. To determine the theoretical curve in each case the ordinate at Y_0 $(X = 0)$

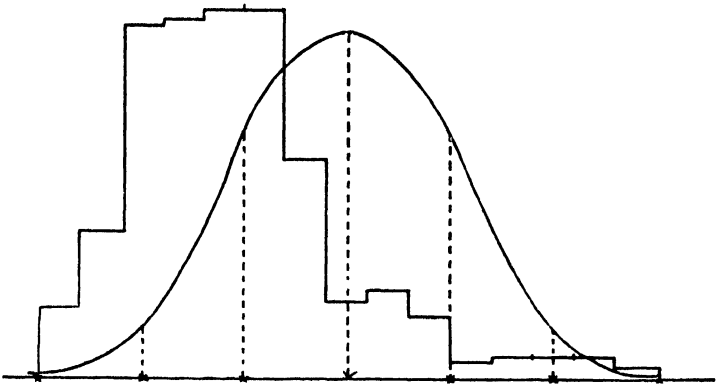


FIG. 3.

was discovered from the equation of the Normal Probability Curve

$$Y = \frac{N}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}$$

and then the ordinates at $\pm\sigma$, $\pm 2\sigma$, $\pm 3\sigma$ (in units of step-intervals) were calculated from the table concerned (Garret's Statistics in Psychology and Education, pp 125–127). The end-points of these ordinates were then joined by means of suitable lines to form the curve required.

From the first two figs. it would appear that the distributions tend to be normal, whereas the third fig. clearly shows that the distribution is far from being such. So, the first of Monroe's assumptions and its corollary fully agree with our findings and therefore one of the expectations comes true.

The reasons for the above phenomena are not far to seek. 'Too easy a test excludes from operation some of the factors which make for an extension of the curve at the upper end of the scale, whereas, too hard a test excludes from operation factors which make for the extension of the curve at the lower end of the scale.' Now the questions in our test are extremely easy for the graduates as anybody can see it, while they are a bit difficult for the lower form students. The two factors have their reflexion on their distributions. But, for the group of students belonging to the higher classes the questions involve factors that make for the chances of distribution and therefore, the extension of the curve even, on either side of the score-ends.

The second assumption of Monroe about the constancy of the variability of the distributions in grade groups has its origin in the findings of different test-makers in America, who have

established that the measures of variability such as σ (sigma), of a given ability or a group of abilities in successive grades tend to remain constant, although in many cases these seem to increase slightly as we advance from the lower to the higher grade. This position exactly agrees with the nature of σ's in Tables 1, 2 and 3. So we see that the second expectation also comes true.

Besides the satisfaction of the two important expectations dealt with above, which are more or less scientific, other expectations from the layman's point of view may be found fulfilled. Tables 1 and 2 show that each measure of students' abilities, namely, Q_1, Q_3, median and mean, increases systematically from the lowest to the highest class, a fact which one naturally expects. Then again, a glance at Table 4 below, which is a consolidated list of percentage of correct responses secured from the students of Patna and Calcutta, will show that in a large majority of cases the responses decrease in magnitude as we advance from the higher to the lower classes. This also is what one expects to be. Thus we conclude that the validity of the test is established.

Of the three methods generally in use for determining the reliability of a test the 'repetition' method is the simplest and the best. This consists in giving the test and then repeating it to the same subjects and lastly in calculating the correlation between the first and the second sets of scores. The correlation thus derived is usually known as the ' reliability coefficient'.

In the present case, our test was applied to two classes at random in two schools at Patna sometime after its first application and the coefficients of correlation calculated by the 'product-moment' formula were found to be ·82 and ·94. The process might have been extended to other classes also, but as it would take much time and labour I had to remain satisfied with these coefficients only, which are without doubt sufficiently high.

The combined distributions for the two top classes both of Patna and Calcutta being normal, we can calculate the 'standard errors' of the respective means to show the extent of their reliability, thus,

For Patna students.

$$\text{The standard error of the mean} = \frac{\sigma \text{ dist}}{\sqrt{N}} = \frac{5{\cdot}78}{\sqrt{735}}$$

$$= \frac{5{\cdot}78}{27{\cdot}1} = {\cdot}21.$$

The statistical interpretation of the above is that the chance is almost 99% of the true mean lying between $15{\cdot}07 \pm 3 \times {\cdot}21$, i.e. between 15·7 and 14·44.

For Calcutta students.

$$\text{The standard error of the mean} = \frac{5{\cdot}5}{\sqrt{461}} = \frac{5{\cdot}5}{21{\cdot}5} = {\cdot}25.$$

The chance is almost 99% of the true mean lying between $14{\cdot}86 \pm 3 \times {\cdot}25$, i.e. between 15·61 and 14·11.

Taking the two results together we may safely say that the 'true' average ability of all the students of the top classes in Bengal and Bihar lies between 15·7 and 14·11, or safer still, between 14 and 16. Thus, the deviations of the 'obtained' means from the 'true' being insignificant, their reliability is fairly assured. As there is no sense in applying this criterion to the two lower forms where the distributions are 'asymmetric', we may depend, in their case, only on the reliability coefficients found from the repetition method as stated above.

In a standardized objective test the qualifying word 'objective' is significant in that a test cannot be good unless the results secured therefrom are free from the subjectivity, i.e. 'the personal equation' of the examiners who mark the answers. In our test the objectivity is amply ensured. Each sum contains the minimum possible work-units, and one point score only is awarded to an answer if it is right and nothing if it is wrong. Thus the assessment of credit being based entirely on the principle of right-or-wrong, there can be no varying opinions, personal bias or the like, regarding the scoring of answers.

As regards the other criterion for the satisfaction of a test, namely, ease of administration and scoring, suffice it to say that in half an hour's time it can be administered to any number of students if only arrangements for strict invigilation are ensured. The ease of scoring will be secured if our 'answer-scale' is used in marking the answers. This is a printed strip of paper always attached to the test pamphlet containing the directions for use and interpretation of results. This strip of paper contains the numbers of the questions and their answers printed in such a way that it can be easily placed on the left hand side of each test paper so that the corresponding numbers of the questions in the two may exactly fit one with the other. Now the numbers of the questions with correct answers may be ticked off and counted, and their totals put down below. This facilitates the scoring to a degree not possible to attain in any examination with which we are acquainted.

Analysis of Students' Responses.

Apart from the measurement of the student's abilities in reasoning arithmetic for which the test was planned there is another important use, namely, the analysis of their responses from educational and psychological points of view. On actual counting it was found that out of 72,120 questions that were

presented to 2,404 students, 1,520 of Patna and 884 of Calcutta, 29,371 were correct and the rest either wrong or untouched. The correct responses were now taken up and counted for each class, question by question, and then their percentages were calculated class by class as well as *en masse*, as shown in Table 4. The column of the total percentages led to the ranking of the questions in order of their difficulty values.

A glance at the table will convince the reader that in a large majority of cases the percentage of correct responses tend to decrease from the higher to the lower classes. But on more careful scrutiny we find that in some cases, especially in the two lower forms their tendency seems reversed. In their attempt to answer some questions students of the lowest class appear to be positively ahead of those of the next higher class. What is it due to? The causes for this anomaly seem to me to be the following:—

In Bihar the students in Class VIII have just finished almost the whole of arithmetic in their Middle Classes, VII and VI, where the subject is taught four or five periods per week, whereas one or two periods a week are allotted to it in Classes VIII and IX. So they begin to forget in these latter classes most of what they have learnt in the middle stage and also lose much of interest in Arithmetic due to the introduction of two new subjects, Algebra and Deductive Geometry, to which more time and attention are given. Thus we can't blame the students *if*, in Class IX, they fare badly in their attempt to tackle some topics of arithmetic or do not make as much progress as they are expected to make. The same position, I presume, holds good in Bengal too.

Almost equal responses made by all classes at Patna to question 2 appear at first sight to indicate that this question is not suitable for the test. But the corresponding figures for the Calcutta boys do not confirm this view. In both the places the responses in the lowest class are about 50%; but while in Calcutta they rise up to 80% in the highest class, in Patna they remain stationary. On closer analysis of answers to this question we find that most of the wrong answers in Patna were due to the presence of the English words 'per pair' which the students must have thought as meaning 'one'. Now when we consider that the test was given in Bengali to boys in Calcutta and in English to all classes at Patna except in the lowest in which the sums were translated in Hindustani and Bengali, it will be clear that the percentage would have increased as in Calcutta had these been given in vernaculars in all the classes.

The percentage of correct responses as shown in the table can be easily utilized in transforming the test into what is called a 'Difficulty Scale'. The method is simple. Take the question for which the percentage of right responses is the largest as the easiest one, and put it first. Take the question for which

TABLE 4.

Patna Schools.						Calcutta Schools.					
Percentage of correct responses, class by class				Percentage, on Total	Ranking of questions on difficulty values	Percentage of correct responses, class by class				Percentage on Total	Ranking of questions on difficulty values
XI	X	IX	VIII			X	IX	VIII	VII		
80·5	75	66	59	69·6	26	80·6	74·8	46	65	67·4	29
50	48	49	50	49·4	20	80·2	68·1	68	52	67·3	28
47	24	17	9	23·3	6	21·4	18	·5	5	12	5
82·3	77·8	80	71	77·4	29	79	62	60·5	54	64	26
39	36	34	30	34·8	14	54·2	42·6	30	30·5	40	15
70	60·3	62·5	59·4	62	23	68	62	56·5	49	59	22
90	87	82	78	83·8	30	82·3	76	63·5	63·2	71·7	30
53	41	37	32	40·3	16	49	44·8	35·5	26	39	14
50	35	22·6	10	28·5	11	6	4·4	4·5	6	5·3	1
84	66·7	66·9	65	70	27	77	69·5	56	48·4	63	25
63·5	48	37	36·6	45·6	19	58	54	30	29	43·4	17
83	62	53·6	30	55·6	22	60	54·7	31	28	44	18
52	32	18	10·5	27·3	9	8	12	1·5	5	6·9	3
82	68·5	45	58	62·7	25	77·3	56	31	44	57·6	21
76	65	53	56·5	62·3	24	77·3	72·7	46	45·7	61	24
25·5	9·8	7·7	10	12·7	3	42	25	13	20·6	15·8	6
35	17·5	12	5	16·5	5	39	15·7	6·5	8	18	7
34	23·9	22·7	22·7	25·4	8	66	48·4	35·5	45·7	50	19
60	35·5	17	10	29	12	44	32	8·5	5·4	23·2	10
53·5	38	30	24	35·5	15	50	51	29	36	42	16
54	48	42	37	45	18	62·6	56·5	43·5	33	50·4	20
57·7	43·3	15	20	33	13	53·3	54·7	8·5	19	35	13
61·4	44	40·7	24·4	41·6	17	44	28	11	12·5	24·5	11
40	28	22·3	11·8	24·7	7	51	28	22	14	29·2	12
27	13·3	12·7	4·8	13·8	4	16	9	4·5	9·4	10	4
43	34·7	17·5	16·6	27·4	10	33·2	23·3	11	14·3	21	8
18	12·5	8	4·8	10·5	2	7·6	5·4	5·5	6·3	6·2	2
11·6	6·6	4	9	7·8	1	25	18	13·5	29	21·6	9
64	54·7	53·3	50	55·1	21	67·2	63·7	56·5	54·7	60·7	23
74	77	70	66·4	72	28	77·3	70	60·5	56	66·2	27

the percentage is less than the preceding one but more than any of the rest and put it second in ascending order of difficulty. Proceed in this way till the remaining question is reached, for which the percentage is the least and consequently the hardest of the questions.

The analysis of responses is of great help to the teacher of arithmetic. By such process he can judge by himself as to which questions are easy and which are difficult for his pupils of different classes and he can take steps accordingly. The Headmaster of a school may see how his classes are making progress by comparing the results of analysis of one year with those of the previous years.

A comparative study of the arithmetical abilities of the students of Secondary Schools in Bihar and Bengal.

When the arithmetical abilities as measured by our test of all the students who were our subjects were distributed in the same frequency intervals, and then represented graphically, as in Fig. 4, one for Patna and the other for Calcutta students, two bimodal curves of like nature resulted, each with one mode between 8 to 10 and the other between 14 to 18 point scores.

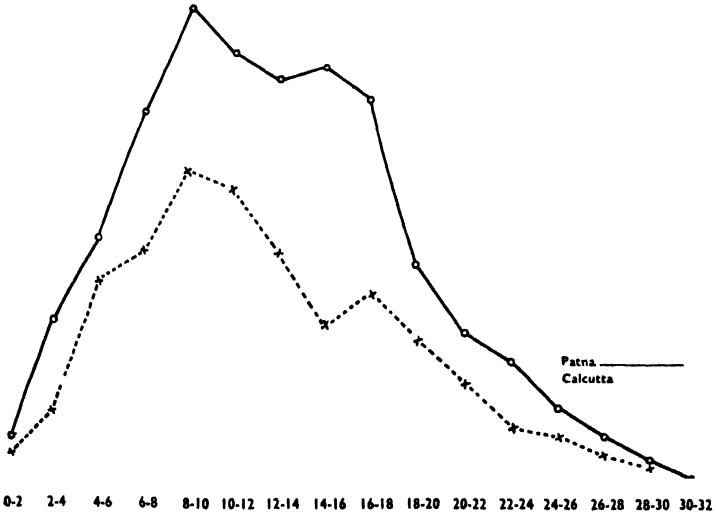


FIG. 4.

If we study this figure along with Table 3 we can easily conclude that in each case there are two distinct groups of abilities, one tending to be normal and the other non-normal.

This fact, which has been already dealt with, will be more clear from Figs. 1, 2 and 3.

Now let us go back to Tables 1 and 2. We find that each of the measures, Q_1, Q_3, median and mean, in both cases increases from the lower to the higher classes at rates that are almost equal to one another. One thing that comes out prominent on closer scrutiny of this rate of increase is the fact that it is extremely slight,—almost imperceptible,—from the lowest to the next higher class, but quite uniform from this latter class upward, and this will appear more clear from Table 5.

TABLE 5.

	Calcutta Classes	Q_1	Median	Q_3	Average
Difference between ..	X & IX	2·7	3·1	5	2·6
Do. ..	IX & VIII	3	3·9	5·3	3·9
Do. ..	VIII & VII	·8	·5	·2	·1
	Patna Classes				
Do. ..	XI & X	3	2·9	3·9	3·2
Do. ..	X & IX	2·2	3·4	2·3	2·4
Do. ..	IX & VIII	1	·6	1·5	1·2

The difference of measures between Classes IX and VIII in Patna is almost negligible while these are prominent and uniform between X and IX, and also between XI and X Classes. Similar is the case in Calcutta. But if we combine the distributions of Classes VIII and IX of Patna and VII and VIII of Calcutta, as in Table 6, we find that the rate of increase is now uniform to a great measure.

From what we have discussed above we may conclude without any fear of contradiction, that about a year's progress in arithmetic, if not in any other subject, is clearly lost to the boys during the first two years of their career in the four top classes of High Schools in both provinces. I have already given some hint about the causes that seem to lead to this situation and now I leave it to the teachers and educationists to ponder over it and devise some remedy if they can.

the percentage is less than the preceding one but more than any of the rest and put it second in ascending order of difficulty. Proceed in this way till the remaining question is reached, for which the percentage is the least and consequently the hardest of the questions.

The analysis of responses is of great help to the teacher of arithmetic. By such process he can judge by himself as to which questions are easy and which are difficult for his pupils of different classes and he can take steps accordingly. The Headmaster of a school may see how his classes are making progress by comparing the results of analysis of one year with those of the previous years.

A comparative study of the arithmetical abilities of the students of Secondary Schools in Bihar and Bengal.

When the arithmetical abilities as measured by our test of all the students who were our subjects were distributed in the same frequency intervals, and then represented graphically, as in Fig. 4, one for Patna and the other for Calcutta students, two bimodal curves of like nature resulted, each with one mode between 8 to 10 and the other between 14 to 18 point scores.

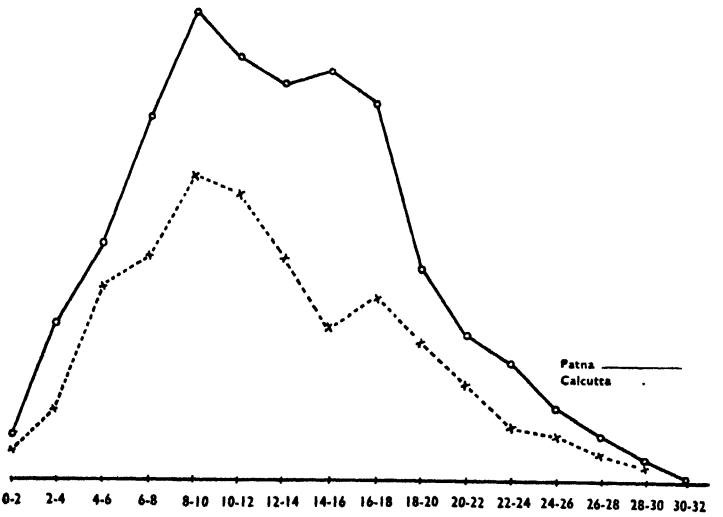


FIG. 4.

If we study this figure along with Table 3 we can easily conclude that in each case there are two distinct groups of abilities, one tending to be normal and the other non-normal.

This fact, which has been already dealt with, will be more clear from Figs. 1, 2 and 3.

Now let us go back to Tables 1 and 2. We find that each of the measures, Q_1, Q_3, median and mean, in both cases increases from the lower to the higher classes at rates that are almost equal to one another. One thing that comes out prominent on closer scrutiny of this rate of increase is the fact that it is extremely slight,—almost imperceptible,—from the lowest to the next higher class, but quite uniform from this latter class upward, and this will appear more clear from Table 5.

TABLE 5.

	Calcutta Classes	Q_1	Median	Q_3	Average
Difference between ..	X & IX	2·7	3·1	5	2·6
Do. ..	IX & VIII	3	3·9	5·3	3·9
Do ..	VIII & VII	·8	·5	·2	·1
	Patna Classes				
Do. ..	XI & X	3	2·9	3·9	3·2
Do. ..	X & IX	2·2	3·4	2·3	2·4
Do. ..	IX & VIII	1	·6	1·5	1·2

The difference of measures between Classes IX and VIII in Patna is almost negligible while these are prominent and uniform between X and IX, and also between XI and X Classes. Similar is the case in Calcutta. But if we combine the distributions of Classes VIII and IX of Patna and VII and VIII of Calcutta, as in Table 6, we find that the rate of increase is now uniform to a great measure.

From what we have discussed above we may conclude without any fear of contradiction, that about a year's progress in arithmetic, if not in any other subject, is clearly lost to the boys during the first two years of their career in the four top classes of High Schools in both provinces. I have already given some hint about the causes that seem to lead to this situation and now I leave it to the teachers and educationists to ponder over it and devise some remedy if they can.

TABLE 6.

	Calcutta Classes	Q_1	Median	Q_3	Average
Difference between ..	X & IX	2·7	3·1	5	2·6
Do. ..	IX & (VIII & VII) combined	3·4	4·1	5·4	4
	Patna Classes				
Do. ..	XI & X	3	2·9	3·9	3·2
Do. ..	X & (IX & VIII) combined	2·7	3·7	3·1	3·1

Let us refer once again to Table 4 to compare the difficulties that the two groups of students found in answering the questions Taking the percentage of correct responses of all the classes for all the 30 questions as given in the two total's columns and applying the 'product-moment' formula used for ungrouped series, namely,

$$r = \frac{\Sigma x^2 + \Sigma y^2 - \Sigma d^2}{2\sqrt{\Sigma x^2 . \Sigma y^2}},$$

we have calculated the correlation of the difficulties as felt by the students of Patna and Calcutta as $r = \cdot 93 \pm \cdot 016$. This close relationship regarding the difficulties of the questions also appears to the eye if the two columns in which these are ranked, are carefully compared. Thus, the difficulty values of the sums tend to be the same for the two groups of students, although this is not so in regard to a few of them. Question 7, for instance, is the easiest for both the groups, but question 28 is the hardest for the Patna students and only 9th in the ascending order of difficulty for the Calcutta students. This fact seems to require more than a passing reference. From my personal experience in the field of the group test of intelligence I know that a high degree of intelligence is necessary for answering the question 28 correctly, and so I was not much surprised when I found that for the Patna students it was the hardest. But my surprise knew no bound when I found that this question was only 9th in order of difficulty for the Calcutta students, although they

lagged behind the Patna students in their responses to as many as 19 out of 30 questions.

The explanation of this phenomenon seems to me to be this: The innate, general ability ('*g*' factor?) of the students of Bengal, on the average, is quite high; but at present they are prevented from bringing their ability into full play in their school subjects on account of various extraneous factors, e.g., undue attraction to non-educational subjects, acute unemployment after Matriculation causing a general lack of interest in school study, unfavourable school conditions, etc.

There are three sums in the test namely, 3, 9 and 13, that involve measurement of area. The responses to these secured from the two groups are widely different,—the Calcutta students faring miserably in each, and one of these, namely, sum 9, has been found to be the hardest for them. This means that sums on areal and linear measurement are not properly taught in the High Schools of Calcutta.

As regards the sum 18 involving tackling of five different coins the percentage of correct responses of Calcutta boys is double that of Patna. Does it mean to say that the Calcutta guardians are more money-minded than their Patna confrères?

In conclusion let me extend my heartiest thanks to those Headmasters and teachers who were so kind to co-operate with me in conducting our test at their schools and also to my numerous students of the Patna Training College who volunteered their services in counting and computation of figures at various stages of my work. My thanks are especially due to the Headmasters of the three High Schools in Calcutta for their hospitality so freely extended to me and their esteemed help in carrying out my work there.

Patna Training College,
Patna.

REVIEWS OF BOOKS.

THE TRAVANCORE TRIBES AND CASTES, VOL. II. By L. A. KRISHNA IYER. Published by the Government Press, Trivandrum, 1939.

The words 'and Castes' in the title of this work are misleading since the author states in his preface that the volumes are the result of twelve months' special duty from September, 1937, 'to complete the ethnographic survey of the Proto-Australoid element in the . . . State'. Records of the social and physical anthropology are given for fifteen tribes (eight in this volume), two more than were dealt with by the author for the 1931 Census. The additions are the begging Nayadis, the Parayans and Pulayans (with the previously included Thantapulayans) who are descended from agrestic slaves and are not Hill Tribes. These three peoples are treated in over half of the 260 pages on social anthropology in Volume II. Little if anything new is added to their ethnology as previously recorded by Aiyappan and Ananthakrishna Ayyar except an interesting account of slavery in Kerala and of recent progress in social uplift, also lists of kinship terms and clan names for the sub-groups of Parayans and Pulayans. The chapter on the Muthuvans gives a good non-technical account of the tribe and its life, but no reference is made to the author's earlier paper on these people. There is a useful map at the beginning of each chapter to show the geographical distribution of the tribe taken up and a frontispiece map of Travancore which gives the distribution of all the tribes treated in both volumes. There are over one hundred photographs in this volume, some of which are very good and will be particularly appreciated by non-Malayalis.

Each of the eight tribes is treated in a separate chapter under several heads such as: origin, structure, marriage, pregnancy, birth, puberty and funeral customs, religion and appearance. These headings are well indexed at the end. Since the author is a Forest Officer readers will regret that very little attention has been paid to ethnobotany. Four of the tribes (Nayadis, Paliyans, Uralis and Vishavans) numbered less than one thousand in the State in 1931. The treatment of these can be characterized in the words of the review of Volume I given in '*Nature*', it 'repeats and amplifies the admirable synopsis of the Census Report for 1931, based on the author's notes'.

The last chapter of 61 pages on physical anthropology contains new material of interest to the professional anthropologist. After a general discussion of the effects of environment, anthropometric work in India and of skin and hair characters, measure-

ments for the following definite characters are given for sixteen tribes (Pulayan and Thantapulayan account for the extra one): Circumference of chest, stature (with percentages of pygmy, short, medium and tall), cephalic and nasal indices (with percentages of three types in each). The samples are of a good size, especially for India, only six are less than 50 and four are over 100, including Kanikkar sample of 240. Beyond the mean for each character and the standard deviation no other data are given. These characters are discussed with excerpts from various anthropologists together with the racial position of the tribes. The author identifies them with the Nishadas of the Vedas and follows other workers in attributing to them a Negrito-proto-Australoid (or pre-Dravidian) descent. He holds with other anthropologists that the more isolated the tribe the higher the nasal index, the more it has crossed with surrounding people the lower the index. At the end there are sixteen lithograph plates with two to four distribution graphs on each for stature, cephalic and nasal indices for each tribe. There is an appendix containing two Pulaya songs in Malayalam, a good general index and an index of exogamous clan names. In a 54 page introduction Baron von Eickstedt contributes a useful outline of the history of anthropological research in India and attempts to force the adoption of a clumsy 'ternary nomenclature of the Indian race types' in which most of the names are quartern, with threats against 'priority' iconoclasts. Since no two taxonomists agree as to the exact nature of species, let alone sub-species, race and 'type', any attempt to erect a rigid technical nomenclature to include them all in modern man can result in nothing more than an academic curiosity. He omits to say where the type specimens of his *Homo sapiens indomelanicus kolidus* and other 'race types' are filed. In his conclusions Mr. Iyer discards Eickstedt's popular designation of 'Weddids' for his tribes, together with 'the time-honoured appellation' of Pre-Dravidian and gives his vote for 'Proto-Australoid' with Sewell and Hutton.

Because the subject-matter dealt with is so important to anthropology and of such interest to cultured persons everywhere it is regrettable to discover signs of inaccuracy, haste and slipshod writing in this work which cannot but cast doubt on the validity of the other data which the reader cannot check. *Examples of Inaccuracy*: (*a*) in Tables IX and X data for Malapantaram, Malavetan, Muthuvan and Kanikkar differ from the same data given for the same tribes in Table VII and previous tables, e.g. Malavetan Nasal Index in Table VII = 89·77 in Table X = 92·7; (*b*) under *Muthuvans* we read 'When a girl attains puberty at the age of fifteen, she is lodged in a separate shed, etc.' What happens if she is younger is not stated. Under 'Vishavans' we learn 'Girls generally attain puberty at about the age of twelve'; (*c*) Tallness in Uralis is laid to their elevated

environment and their robust build 'is due to the rarified air of 3,000 feet'. On the other hand, the fact that the tallest tribe is the Southern Pulayas of the lowlands is credited to 'the dry healthy climate and high nutritive content of their food' (no account is given of this valuable diet). *Examples of hasty work and slipshod writing*: (*a*) The author's conclusion after thirteen pages about the Paliyans: 'The Paliyans are good singers like the Mannans. They are lazy and try to carry on with the minimum of labour.' (*b*) His conclusions for twenty-four pages on the Ullatans is a quotation from Visscher who wrote in 1862 that they wear no clothing 'and regard the tiger as their uncle' and recorded customs with regard to this 'relative' to which Mr. Iyer adds, 'They no longer observe these customs'. (*c*) From page 182, we learn that among the Pulayas 'to be crossed by a cat' is a bad omen.

The work is evidently faulty but because of the intrinsically valuable subject both this and the previous volume will make very interesting reading for the undergraduate and lay reader. A glossary of the Malayalam terms would have been helpful.

Throughout Volume II the bibliographical references are given in footnotes and on the very last page there is an alphabetical list of bibliography. The latter is most incomplete, in many cases authors' initials and dates of publication are omitted; Ernest Crawley is placed under *E*, Herbert Spencer under *H* and Robert Lowie under *R*. All this must embarrass the gentlemen who are thanked for help in editing in the author's preface.

Those who have already purchased Volumes I and II may be interested to learn that Volume III is merely a repetition of what has been given with a transcription of the article on 'The Primitive Tribes of Travancore' by Iyer and Pillai from Volume I of the 1931 Census of India.

E. W. E. MACFARLANE.

THE TRAVANCORE TRIBES AND CASTES. THE ABORIGINES OF TRAVANCORE, Vol. III. By L. A. KRISHNA IYER. Published by the Government Press, Trivandrum, 1941.

The author in his preface says that this last volume of his work contains his 'conclusions on the study of the tribes to which blood grouping studies have yielded additional evidence. It attempts an interpretative glimpse of the inner life of the tribes .. It gives an exposition of primitive culture in all its aspects'.

After a short introduction by Professor Marett the first chapter is a transcription of pages 262–279 in the last chapter of Volume II on physical anthropology. Even the same mistake is repeated on page 11 of attributing to Hodson an excerpt from

Guha's introduction to the 1931 Census Report. Then follows Chapter II 'Traditions of Origin' which is an exact transcription from pages 231–233 of the article by Iyer and Pillai in 1931 Census of India, Vol. I, although this is not referred to by footnote nor in the list of bibliography. Chapter III is a transcription of the second half of the last chapter of Volume II, including the conclusions in full; two pages about blood group data are interpolated. The tables of physical measurements, with the same inaccuracies, are copied from Volume II but they are no longer numbered consecutively, those in Chapter III starting off as Tables I, II, etc. again. On page 34 Iyer says: 'I give below the results of my study based on extensive measurements of the primitive tribes of Travancore.' Two tables follow (Chap. III, Tables I and II) and the first contains Thurston's data without his name being mentioned; in Volume II, Table VI, the same data are given as 'recorded by Thurston'. At the back of the volume the same lithograph charts from Volume II are reproduced, together with the same error of giving the scale for the distribution charts of cephalic and nasal indices as '1 inch = 10 cms.'

Chapter IV on Megalithic Monuments is also transcribed from the 1931 Census Report with a few sentences added. Chapter V on Domestic Life is taken partly from the Census Report and partly from the author's paper 'The Primitive Culture of Travancore' (*Proc. Ind. Acad. Sci.*, 4: 435–453, 1936), which is not referred to in the bibliography either. These two older papers by the author have also been resurrected to make the next six chapters, with the addition of an occasional sentence or paragraph here and there.

Nearly all the data on social anthropology in Volume III were thus already collected in 1931, nearly ten years ago, and now they are presented again as 'conclusions'.

The blood grouping data of Dr. Karunakaran for 211 Kanikkars in Chapter I are interesting in that they differ from those for other West Coast Tribes in showing more of Group B than of Group A. The author, however, insists that the figures 'very nearly approximate' those for Australians (who are known to be almost devoid of Group B) and attributes the 29·8% Group B in the Kanikkars to 'miscegenation with the high caste Hindu'. The three tables presenting blood group data have no numbers. In the second the data for 'Pre-Dravidians' taken in Cochin State by Macfarlane are here attributed without evidence to the Kadar Hill Tribe. The papers from which other blood group data are taken for comparison are not given in the bibliography.

The following definition of *Hinduism* on the chapter on Religion is apparently new to the author's writings and one wonders how it would have been received from a non-Hindu—'animism more or less transformed by philosophy, or to condense the definition, as magic tempered by metaphysics'.

There are over sixty photographs, some very good, most of which have already appeared in the Census Report and in the first two volumes. There is an index, an alphabetical list of names of endogamous clans and an incompletely documented bibliography.

For those who have not already purchased the first two volumes of this work the third volume provides a lot of interesting matter about some fascinating tribes in a handy form with good illustrations.

E. W. E. MACFARLANE.

CLASSIFICATION OF FISHES, BOTH RECENT AND FOSSIL.[1]

In 1924, while reviewing some American work on recent and fossil fishes, it was pointed out by the late Dr. N. Annandale and the present writer [2] that as regards bibliographical monographs ichthyologists are perhaps in a much better position than the students of any other group of animals. The great value of the monographs then reviewed has been fully realized during the last 17 years and at the present day no serious student of fishes can be without Dean's 'A Bibliography of Fishes', of which another volume is long overdue, and Jordan's 'The Genera of Fishes' and 'A Classification of Fishes'. From time to time, C. Tate Regan has been publishing an elaborate classification of all the recent fishes based on his own extensive osteological researches, and in 1929 he codified these in his article on 'Fishes' (pp. 305–328) in the 14th edition of *Encyclopaedia Britannica*. As no reprints of this learned article were published, it is unfortunately not easily accessible to many ichthyologists and has, in consequence, been little used. Quite recently, the Russian savant, Professor Leo S. Berg [3], has brought out a work of unusual interest on the classification of fishes, in which he not only gives his views but includes concise and critical summaries of the earlier systems of classification and in foot-notes refers to the relevant recent literature on the subject. In the text brief notices are included upon the geological and geographical distribution of the families and the names of extinct groups of fishes are marked with a dagger. The structural peculiarities characteristic of the various groups are well illustrated.

[1] Berg, L. S.—Classification of Fishes, both Recent and Fossil. *Travaux Inst. Zool. Acad. Sci. URSS*, V, pt. 2, pp. 517. (Russian text up to page 345), 190 text-figs. (1940).

[2] Annandale, N. and Hora, S. L.—Fish: Recent and Fossil. *Journ. Proc. Asiat. Soc. Bengal* (N.S.), XIX, pp. 101–103, 1923 (1924).

[3] Professor L. S. Berg was awarded the Society's Joy Gobind Law Memorial Medal in 1936 for conspicuously important contribution to the knowledge of Zoology in Asia.

Berg is of the opinion that there is no reason to apply the rule of priority to taxonomic units higher than genera, and, therefore, for families he has adopted names widely known in literature. In this connection, he makes the following observations, with which the reviewer entirely agrees:

> 'Some authors believe, for some reason or other, that families must bear names after the first described genus. Such an obligatory rule does not exist, and the use of that principle can only lead to confusion. As concerns the genera, we adopt, generally speaking, the principle of priority, but within reasonable limits. I think it is inadvisable to reject, in deference to a "law" of priority, the old names which are widely used in the anatomical and biological literature and to replace them by names extracted from worthless and justly forgotten writings of a Rafinesque or Swainson. It seems to me that the long practice, of more than half a century, in the application of the "law" of priority has shown the complete worthlessness of this principle. Instead of putting the nomenclature in order it has thrown it into an inextricable confusion. Owing to the "law" of priority, it happens not infrequently that even a specialist cannot, without special references, make head or tail of the nomenclature.'

It is suggested that as regards genera 'enquiries into priority beyond the limit of XIX century should be prohibited (except, of course, for Linne); moreover, as regards the genera of Cuvier, which are widely used in the anatomical and biological literature, the rule must be established that "la recherche de priorité est interdite". On the whole, I agree with Heikertinger that the "law" of priority cannot be observed when we have to do with names having a wide currency'.

The above observations on the law of priority deserve very serious consideration, and it is time that a more workable nomenclatorial system should be adopted. At present, much time has to be spent in hunting for older names and justifying their use in current literature.

Seeing the mass of valuable information, properly documented, on the classification of recent and fossil fishes that has been brought together by Professor Berg in this work the great debt we owe to him is clear without further comment. Our gratitude is still greater, for besides the Russian text, there is a complete text, with the exception of text-figures, in English also. References to text-figures are, however, given in the English text and the explanations of the text-figures in English are also appended.

S. L. HORA.

INSTRUCTIONS TO AUTHORS FOR THE SUBMISSION OF PAPERS FOR PUBLICATION IN THE JOURNAL AND MEMOIRS OF THE SOCIETY.

PAPERS

1. All communications submitted to the Society for publication should be addressed to the General Secretary and not to any officer by name. They should be type-written on one side of the paper with sufficient margin on the sides, and *in all respects must be absolutely in their final form for printing.*

2. Papers must be accompanied by a brief abstract not exceeding 1,000 words, which shall indicate the subject of the paper and the nature of the advance in the existing knowledge on the subject.

3. Tables of contents (for long papers), references to the plates and literatures, etc., should be given in their proper places.

4. Quotations in Oriental languages should be in the original script, and wherever they are transliterated the System of Transliteration adopted by the Society must be followed (see instruction 15). The names of *genera* and *species* in the case of biological communications should be underlined to indicate that they are to be printed in italics.

ILLUSTRATIONS

5. All drawings and photographic prints should be as clear as possible. They should be in a form immediately suitable for reproduction, preferably of a size to permit reduction to about two-thirds the linear dimensions of the original, and should be capable of reproduction by photographic processes.

6. Drawings and diagrams to be reproduced as line blocks should be made with fixed Indian ink, preferably on fine white Bristol board, free from folds or creases; smooth clean lines or sharp dots, but no washes or colours should be employed for shading. The positions of the illustrations that are to appear in the text must be clearly indicated in the margin of the paper; and explanations of the figures should be typed at the end of the main paper with the indication: *Explanation of text-figures.*

7. The maximum space allowable for illustrations in the *Journal* and the *Memoirs* are as follows:—

Journal, *text*, $3\frac{1}{4}'' \times 6\frac{1}{4}''$; *Plates*, $4\frac{1}{2}'' \times 7''$.
Memoirs, *text*, $6\frac{1}{4}'' \times 9''$; *Plates*, $7\frac{1}{2}'' \times 9\frac{1}{2}''$.

These spaces include the usual figure numbering. Explanations of the plates to be printed on separate pages, facing the plates, must be typed on separate sheets.

PROOFS

8. A proof of each paper will be sent to the author, on the address given on the MS.

9. No alteration or addition necessitating any considerable change of type may be made in the proofs. Should such alterations or additions be necessary, these must be added as footnotes duly dated and initialled. The cost of corrections made in the proofs should not exceed 20% of the printers' charges for the setting of the paper; any excess will be charged to the authors.

10. The proof must, if possible, be returned within one week of the date of receipt to the Society duly corrected.

MISCELLANEOUS

11. Authors of papers published in the Society's *Journal* and *Memoirs* are entitled to receive *gratis* 30 copies of each paper, and as many more as they require on payment of the cost of printing, paper, and make up. Such requirements must be stated at the time of returning the proofs.

12. Papers by non-Members of the Society must be communicated through a Member, who shall satisfy himself that the paper is suitable for presentation to the Society, and is ready for the press.

13. No communications under consideration or accepted for the Society's publications may be published elsewhere without the express sanction of the Council.

14. To facilitate the compilation of indexes, each author is requested to return to the Society together with the proof, a brief index of the contents of the paper. These indexes will be edited and incorporated in the volume when completed.

15. The following systems of transliteration are henceforth to be followed (as far as practicable) in the publications of the Society, in quoting non-European words as such. In giving names of places, authors or books, which would occur in the course of the English text, a 'broad' transcription, following English values of the consonants and avoiding diacritical marks, is recommended.

SANSKRIT

अ = a आ = ā इ = i ई = ī उ = u ऊ = ū

ऋ = ṛ ॠ = ṝ ऌ = ḷ ए = e (or ē) ऐ = ai (or a͟i)

ओ = o (or ō) औ = au (or a͟u) (Prakrit अइ अउ = aï, aü)

ं (*Anusvāra*) = ṃ : (*Visarga*) = ḥ × (*Jihvāmūlīya*) = χ

ᳺ (*Upadhmānīya*) = ϕ

Sandhi Vowels may be indicated as â î û ê ô. *Avagraha*='.

Accents in Vedic—*Udātta* á ǽ etc. *Svarita*—à.

क	ख	ग	घ	ङ	=	k	kh	g	gh	ṅ (or ŋ)
च	छ	ज	झ	ञ	=	c	ch	j	jh	ñ (or ɲ)
ट	ठ	ड	ढ	ण	=	ṭ	ṭh	ḍ	ḍh	ṇ
त	थ	द	ध	न	=	t	th	d	dh	n
प	फ	ब	भ	म	=	p	ph	b	bh	m
य	र	ल	व		=	y	r	l	v (or w)	
श	ष	स	ह		=	ś	ṣ	s	h	
ळ	ळ्ह				=	ḷ	ḷh			

HINDI (and other North Indian Speeches)

As for Sanskrit, only nasalised Vowels are to be indicated by a *tilde* mark (~) above the Vowel (e.g. अं आं जं ऐं = ã ãĩ ũ a͟ĩ

etc.), and ড় ঢ় are to be denoted optionally by either ḍ ḍh or by ṛ ṛh. Care should be taken in distinguishing ব and ৱ (*b* and *v*)—the latter preferably may be written as *w* rather than *v*, specially in intervocal and final positions. The final silent *-a* may be optionally omitted: but in quoting Early Hindi, etc. the final *a* should be retained. ঙ ঙ্ক as in Rajasthani, Panjabi, etc. are to be indicated as in Vedic.

BENGALI

The system for Sanskrit, with the provision for nasal Vowels and for ড় ঢ় (= ড় ঢ়) as in Hindi. For য (অন্তঃস্থ য), in all *tatsama* or pure Sanskrit words, *y* should be employed, in Prakritic and semi-tatsama words, *j*; subscribed য (= য-ফলা) should be indicated by *y*. The difference between বর্গীয় ব (= *b*) and অন্তঃস্থ ব (= *v*, *w*) need not be indicated for Bengali—*b* may be written for both: only subscribed ব (ব-ফলা) is to be written as *w* (e.g. Skt. *Viśvāsa* = Bengali *Biśwās*). Final *-a* may be omitted optionally, but it should be retained for Early Bengali.

ARABIC

In transcribing Arabic, according to the context either (i) the native Arab pronunciation (as current in the *Jazīratu-l-'Arab*) or (ii) the Perso-Indian pronunciation may be followed

(i) Arabic in native Arab Pronunciation—

ء أ (*alīf hamza*) = ʾ; ب = b, ت = t, ث = th (or θ); ج = j (or ǧ), ح = ḥ, خ = kh (or χ, or x); د = d, ذ = dh (or δ); ر = r, ز = z; س = s, ش = sh (or š); ص = ṣ, ض = ḍ; ط = ṭ (or t), ظ = ẓ (or ẓ); ع = ʿ, غ = gh (or γ); ف = f, ق = q; ك = k; ل = l; م = m; ن = n; و = w, ū; ه = h; ى = y, ī.

ـُ ـِ respectively = a, i, u (or ă, ŏ optionally in place of i, u), ا = a, i, u; آ ـا = ā; ـِي ـِ = ī; ـُو = ū; ـَي = ay (or ai); ـَو = aw (or au); *tanwīn* = un, an, in above line; ـى = á. (*Note:* عبد الحق = 'Abdu-l-Ḥaqq, or 'Abd al-Haqq, not 'Abd-ul-Haqq.)

ة = t (or h, or th).

(ii) Arabic in Perso-Indian Pronunciation, in the case of the following letters—

ث = ṡ, ذ = ż, ص ض = ṣ ẓ, ط ظ = ṭ ẓ.

PERSIAN

As for Arabic in Perso-Indian Pronunciation, with the following special Persian letters added:

پ = p, چ = ch (or c, or č), ژ = zh (or ž), گ = g.

و may be indicated for Persian by v rather than w.

For Early Modern Persian, and Indian pronunciation of Persian, the *majhūl* sounds of ی and و (= ē, ō) may be employed side by side with the *ma'rūf* sounds (= ī, ū).

ے ے = au, ai. Nasalisation (*nūn-i-ghunna*) may be indicated by *tilde* mark (~) on the top of the Vowel, as in the case of Hindi, etc.

Hā-i-mukhtafī can be represented optionally as ah or a.

The *Iẓāfat* is to be written as -i- (or -ĕ- optionally).

URDU

As for Persian, only و = w, rather than v. See also the directions for Hindi. The special Urdu letters in the Perso-Arabic alphabet for Urdu are to be transcribed as in Hindi, e.g. ٹ = ṭ, ڈ = ḍ, ڑ = ṛ (or ṙ).

TAMIL

In transcribing Old Tamil, the modern pronunciation should not be followed—an exact transliteration will be enough for the purpose. This is in case of the consonants, which for Old Tamil should be indicated as below:—

க = k (never g, even medially); ங = ṅ (or ŋ)

ச = c (never ś, or j); ஞ = ñ (or ɲ)

ட = ṭ (never ḍ, even medially); ண = ṇ;

த = t (never d, or th); ந = n;

ப = p (never b, or v); ம = m;

ய ர ல வ = y, r, l, v; ள = ḷ; ன = n'; ற = r' (ன்ற = n'r', not ndr; ற்ற = r'r', not tt); ழ = ẕ (or l̤); ஃ (*āytam*) = ḥ.

Long ē and Long ō are to be distinguished from the corresponding short vowels by the *macron* or length mark—the short e and short o being left unmarked.

TIBETAN

Vowels—	a	i	u	e	o
Consonants—	k	kh	g	ṅ	(or ŋ)
	c	ch	j	ñ	(or ɲ)
	t	th	d	n	
	p	ph	b	m	
	ts	tsh	dz	w	
	ž	z	'(or ḥ)		
	y	r	l š	s	h

Silent letters need not be attempted to be indicated in transcription, but if necessary, the modern pronunciation may be denoted by some consistent system of phonetic transcription within brackets after the transliterated Tibetan (or *vice versa*).

CHINESE

Usually the North Mandarin Pronunciation should be represented, in Wade's system, with tones denoted by numerals. As far as necessary or practicable, the original Chinese character and the reconstructed pronunciation of it in Ancient Chinese should be given within brackets.

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ARTICLE No. 1.

Tibetan and Bhotia Blood Group Distributions.

By EILEEN W. E. MACFARLANE.[1]

In 1937 a small sample (56) of Tibetan bloods was grouped at Kalimpong on the southern end of the Tibetan trade route in North Bengal (Macfarlane, 1937). In November 1941 a visit was made to Darjeeling in the foot-hills of the Himalaya Mountains a few miles west of Kalimpong and over a hundred more of these people from various parts were grouped. Bloods from sixty-five were also typed for M and N. They are generally very independent and superstitious and it is difficult to persuade them to give a little blood. Thanks to the co-operation of some local school authorities and missionaries, I was able to get both children and adults. It was not without a struggle that 117 blood samples were obtained. From these five sibs must be subtracted leaving 112 only.

The term Bhotia (or Bhutia) is a general one for Tibetans and certain hill people of Bhutan, Nepal and Sikkim States who possess some Tibetan intermixture. In the 1931 Census (Porter, 1933) 29,404 Bhotias were recorded from the Darjeeling District of Bengal. They were separated into the following four divisions: (*a*) *Bhotia of Bhutan* (Drukpa, Dukpa), (*b*) *Bhotia of Nepal* (Sharpa, Kahm, Nag Chhong, Salakha, Shakzang), (*c*) *Bhotia of Sikkim* (Dejong-Lhari, Dengongpa, Lhopa Bhotia), (*d*) *Bhotia of Tibet.* They are of course Mongoloids and the strain has been characterized by Guha (1937) as follows: 'medium to tall stature, round broad head and face, with high cheek bones and long flat nose. There is very little hair on the face and body and the skin colour is light brown tinged with a reddish tint'.

In Darjeeling the Tibetans tested were mostly poor people—mule drivers, coolies and beggars. In Nepal, Bhutan and Sikkim the Bhotias are a mixture of Tibetan and aboriginal strains, such as the Lepchas. Neither sex has any scruples against racial admixture, therefore the data from the Bhotias born in Tibet have been separated from those born in Sikkim and the Darjeeling District. The Tibetans were chiefly from Central Tibet (Shigatse and Lhasa) or Eastern Tibet (Chumbi, Kham and Yatung). Some of them may be mixed with the Chinese (Macfarlane, 1937). Including the 1937 data (from which three sibs have been subtracted leaving 53) there are altogether 80 Tibetan Bhotias (41 tested in 1937) and 85 from Sikkim and Darjeeling District

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(12 tested in 1937). These data are given in Table I together with the blood group distribution found among the 112 mixed Bhotias in 1940 and in a total of 165 mixed Bhotias made up of the latter plus the 53 grouped in 1937.

The Tibetan Bhotias show over 9% more of Group A than the mixed Bhotias and over 10% less of Group AB. Although the two samples are small these differences indicate that in the region of Sikkim the Tibetans, rich in agglutinogen A, are mixing with people who have more of Group B. I still have data from only 33 Lepchas (8 more than in 1937) and the numbers found within the different blood groups are: Grup O 10, Group A 12, Group B 9, Group AB 2. Only one sample of less than a hundred mixed Nepalis has been published (Macfarlane, 1937).

It has been pointed out by Boyd (1939) that according to Bernstein's theory of the inheritance of the blood groups, which is now thoroughly established, the sum of the frequencies of the three genes $(p+q+r)=1$, except for chance deviation; when the difference actually found (D) is divided by its standard deviation (σ) the result should not exceed 2, where the variations are due to chance. In this way Boyd has tested all available anthropological blood group data. When D/σ is more than 2 the data are 'unsatisfactory, due to inhomogeneity of the population, or errors in technic, or both'. (Boyd.)

The values of D/σ for the different samples in Table I are interesting. For Tibetan Bhotias, the value is only 0·5, while for the Bhotias born in Sikkim and Darjeeling it is 3·06. Errors in technique may be ruled out since the two sets of data were collected together and sorted out later. Therefore this high value for D/σ may be attributed to the recent racial interbreeding that is occurring among the Bhotias south of Tibet. If these two groups had not been examined separately no indication of the race mixture would have been gained from the mixed samples because the intermediate value of D/σ which is obtained is not larger than what might be due to chance.

In a sample of 187 Tibetan bloods grouped at Lhasa by Tennant and reported by Gates (1935) the extraordinarily high percentage of 24·1 of Group AB was found ($D/\sigma=4·21$). In Boyd's list (1939) among 49 samples from all parts of the world showing over 15% Group AB 40 have a value for D/σ of over 2·0. In cases where the technique used can be relied upon percentages of Group AB of this order also seem to indicate a racially mixed sample or genetic inequilibrium in the population.

The Bhotias from Sikkim and Darjeeling grouped in 1940 were mostly boarders and day pupils in the local colleges and schools.

In Table II blood group distribution in all Bhotias tested is compared with that found in the Khasis at Cherrapunji, Assam, in 1939 (Macfarlane, 1941) and in Chinese in Hu-Nan, central China (Li-Chi-Pan, see Boyd).

The Khasis are a matriarchal tribe of mongoloid aborigines of the Khasi Hills, Assam, and are known to be somewhat mixed genetically. Their traditions say that they came from the north and their blood group distributions are of the same order as those among the Bhotias. The Lushai and Angami Naga of the mountains of east Assam also show high percentages of Groups O and A but less of Groups B and AB than the Khasis (Mitra).

Most of the blood group data from the Chinese populations (Boyd) are from eastern areas and show more of Group B than found in the Bhotias or Khasis, but in the large sample from Hu-Nan the distribution is of the same order. This indicates that the blood group distribution among mongoloid peoples in a large area from western China through Tibet to the Himalayan States and central Assam is much the same, although the final proportions may have been brought about by different racial ingredients.

Blood Types.—A limited amount of anti-M and anti-N fluids were available and 65 bloods from Bhutias born in Sikkim and Darjeeling District were typed (see Table III). Even though the sample is small the results resemble closely those of the distribution of blood types among a population of mixed Indians (mostly Bengalis) at Calcutta (Greval *et al.*) Type N seems to be scarce (under 10%) among the Bhotias as it is among the mongoloid American Indians. Chinese at Hong Kong were found to have 18·2% of Type N (Ride in Boyd). These and the Japanese have a blood type distribution resembling that found in western Europe.

Summary.—1. One hundred and twelve mixed Bhotias were grouped at Darjeeling, North Bengal. They showed less of Group B than of Group A and over 10% of Group AB.

2. When those born in Tibet were separated from those born in Sikkim or Bengal the former were found to be genetically in equilibrium serologically and the latter showed signs of racial mixture.

3. The Bhotias of Sikkim are known to have interbred with the Lepchas. They show three times as much of Group AB as the Tibetans, and this increase is at the expense of Group A.

4. The blood group distribution in mixed Bhotias is of the same order as that found in the Khasis of Assam.

5. A small sample of bloods was typed and indicates that Type N is scarce among the Bhotias and that the types are distributed as among the Bengalis.

Table I. The Distribution of the Blood Groups among Bhotias.

Description of Sample.	No.	Nos. and Percentages in Groups.				Frequencies.			
		O	A	B	AB	*p*	*q*	*r*	D/σ
Mixed Bhotias, 1940	112	38 *33·92*	36 *32·14*	25 *22·32*	13 *11·61*	·230	·168	·582	1·25
All Bhotias, 1937 & '40	165	61 *36·97*	53 *32·12*	34 *20·61*	17 *10·30*	·223	·151	·608	1·5
Born in Tibet	80	31 *38·75*	29 *36·25*	16 *20·0*	4 *5·0*	·243	·144	·622	0·5
Born in Sikkim and Darjeeling District	85	31 *36·47*	23 *27·07*	18 *21·17*	13 *15·29*	·193	·154	·604	3·06

Table II. Blood Groups in Bhotias, Khasis and inland Chinese.

People.	No.	Percentages in Groups.				Frequencies.			
		O	A	B	AB	*p*	*q*	*r*	D/σ
Bhotias (mixed)	165	36·976	32·121	20·606	10·303	·223	·151	·608	1·5
Khasis (Macfarlane)	200	33·0	35·0	18·5	13·5	·261	·168	·563	1·7
Chinese of Hu-Nan (Li-Chi-Pan)	1296	31·9	39·0	19·4	9·8	·277	·150	·565	1·4

Table III. Blood types M and N in Bhotias (mixed).

People.	No.	Nos. and Percentages in types.			Frequencies.		
		M	MN	N	*m*	*n*	D/σ
Mixed Bhotias ..	65	28 *43·1*	32 *49·2*	5 *7·7*	·667	·298	5·61

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ARTICLE No. 2.

Observations on the method of Carp Culture in the so-called Salt Lakes near Calcutta, with a note on the Fish Fauna of the Lakes.

By PURNENDU SEN.

(Communicated by Dr. S. L. Hora.)

I. INTRODUCTION AND GENERAL CONSIDERATIONS.

The Salt Lakes to the east of Calcutta have long been known for the abundance of their fish fauna, which up to a few years ago consisted mainly of brackish water forms such as *Lates calcarifer* (Bloch) and *Mugil parsia* Ham. (Gupta, 1908). *Hilsa ilisa* (Ham.) was also not uncommon when the lakes were fed by water from the tidal river Bidyadhari which of late has silted up; there is at present no ingress of saline water into the Salt Lakes from this source. Sewell (1934) in studying the fauna of the Salt Lakes also remarked on the rapid deterioration of the river Bidyadhari owing to deposition of silt during the flood tides. The natural process of delta-formation and the consequent changes in the river system, as also engineering constructions, such as bridges and canals, have also been instrumental in bringing the present moribund condition of the river (Sewell, 1934).

As a result of this deterioration and through repeated dilutions with rain water during the last few years the chlorine content of the lakes has decreased considerably (Table I), as

TABLE 1.

Salinity in the Salt Lakes

Year.	Chlorine contents per 100,000 parts.
1928	1,499 [1]
1936	950
1939	640
1940	130

N.B.—Readings were taken during the dry seasons from a northern point in the Salt Lakes (North).

[1] This figure obtained by Dr. K. P. Biswas is quoted by Sewell (1934), p. 59 and Neogi, S. K. (1936), *Rec. Mal. Survey of India*, VI, p. 43.

already pointed out by Sewell (1934) who came to a definite conclusion that the water in the lakes was gradually becoming more and more fresh. The vast water area of the lakes is consequently more and more utilized for the culture of freshwater species especially the carps. Several fish culture ponds have been started in the villages bordering on the Salt Lakes, and the lakes themselves are being more and more bunded up into small reservoirs or 'bheris' as time passes (*vide* Gupta, 1908).

II. Fish fauna of the Salt Lakes.

In directing routine surveys of Anophelines in the area, I kept field notes of the fish which were found in the Salt Lakes and in the several fish culture ponds. The various species of fish and common crustacea found in the Salt Lakes during the years 1937 to 1940 are listed in Table II.

Table II.

List of fishes and crustacea available in the Salt Lakes.

Scientific Names.	Local Names.
Pisces	
Family Megalopidae	
1. *Megalops cyprinoides* (Broussonet).	Amlet.
Family Clupeidae	
2. *Engraulis telera* (Ham.).	Fesha—Phansa*.
Family Notopteridae	
3. *Notopterus notopterus* (Pallas).	Folui—(Phola)—Pholui*.
Family Cyprinidae	
Subfamily Abramidinae	
4. *Chela bacaila* Ham.	Chela—Chela*.
Subfamily Rasborinae	
5. *Esomus danricus* (Ham.).	Danrke—(Danrica)—Danrika*.
Subfamily Cyprininae	
6. *Amblypharyngodon mola* (Ham.).	Maurala—Mawrala*.
7. *Barbus* (*Puntius*) *sarana* (Ham.).	Swarna punti—(Sarana)—Sarana punti*.
8. *Barbus* (*Puntius*) *sophore* Ham.	Safari punti—Punti*.
9. *Barbus* (*Puntius*) *ticto* Ham.	Tit punti—Tita punti*.
10. *Catla catla* (Ham.).	Katla—(Catla)—Katla*.
11. *Cirrhina mrigala* (Ham.).	Mrigal—(Mrigala)—Mrigala*.
12. *Cirrhina reba* (Ham.).	Kharke bata—(Batta)—Kharke-batta*.
13. *Labeo bata* (Ham.).	Bata—(Dommarci batta)—Bhangna*.
14. *Labeo calbasu* (Ham.).	Kalbose—(Kalbasu)—Kalbasu*.
15. *Labeo gonius* (Ham.).	Kurchi bata—(Karchi)—Karchi*.

N.B.—The local names in brackets and those marked with asteriaks are according to Day (1876–78) and Shaw and Shebbeare (1937) respectively.

TABLE II (*continued*).

Scientific Names.	Local Names.
16. *Labeo rohita* (Ham.).	Rui—(Ruee)—Rui*.
Family Clariidae	
17. *Clarias batrachus* (Linn.).	Magur—(Mahgur)—Magur*.
Family Heteropneustidae	
18. *Heteropneustes fossilis* (Bloch).	Singi—(Singee)—Singhi*.
Family Siluridae	
19. *Wallagonia attu* (Bloch).	Boal—(Boyari)—Boal*.
Family Bagridae	
20. *Mystus tengara* (Ham.).	Tangra.
Family Cyprinodontidae	
21. *Aplocheilus panchax* (Ham.).	Techoke—(Panchax).
22. *Oryzias melanostigma* (McClelland).	Chuno.
Family Hemirhamphidae	
23. *Hemirhamphus limbatus* C.V.	Bogu.
Family Ambassidae	
24. *Ambassis nama* (Ham.).	Katchanda—Nama chanda*.
25. *Ambassis ranga* (Ham.).	Ranga chanda—(Chandee)—Ranga chanda*.
Family Ophicephalidae	
26. *Ophicephalus gachua* Ham.	Chang—Cheng*.
27. *Ophicephalus punctatus* Bloch.	Lata—Taki*.
28. *Ophicephalus striatus* Bloch.	Sole—(Sol)—Shol*.
Family Osphronemidae	
29. *Colisa fasciata* (Bl. Schn.).	Khalisa—Khalisha*.
Family Anabantidae	
30. *Anabas testudineus* (Bloch).	Koi—(Coi)—Koi*.
Family Nandidae	
31. *Nandus nandus* (Ham.).	Nadas—(Latha)—Nandus*.
Family Gobiidae	
32. *Glossogobius giuris* (Ham.).	Bele—Beley*.
Family Mugilidae	
33. *Mugil corsula* Ham.	Khorsola—(Corsula).
34. *Mugil parsia* Ham.	Parse—(Tarui).
35. *Mugil tade* Forsk.	Bhangan (Bangon).
Family Scatophagidae	
36. *Scatophagus argus* (Bloch).	Pyra chanda.
Family Mastacembelidae	
37. *Mastacembelus pancalus* (Ham.).	Pankal—(Pangkal).
Crustacea	
Family Palaemonidae	
1. *Palaemon lamarrei* M.-Edw.	Kucho chingri.
2. *Palaemon carcinus* (Fabr.).	Mocha or Golda chingri.
Family Penaeidae	
3. *Penaeus carinatus* Dana.	Bagda chingri.
4. *Metapenaeus monoceros* (Fabr.).	Honye chingri.
Family Portunidae	
5. *Scylla serrata* (Forsk.).	Nona kankra.
Family Grapsidae	
6. *Varuna litterata* (Fabr.).	Chiti kankra.

N.B.—The local names in brackets and those marked with asterisks are according to Day (1876–78) and Shaw and Shebbeare (1937) respectively.

Lates calcarifer (Bloch) or the '*bhetki*' has become extremely rare in the area. It has been replaced by the carps; these do not breed in confined water but are introduced into the Salt Lakes area almost every year from distant nurseries. Fish like *Mystus tengara* and the mugils are also introduced in the shallow fish ponds of the area at fry or young stages from the navigation canals (Pl. 1, Fig. 1) bordering on the Salt Lakes and the '*bheris*'.

The Culture of Carps in the Salt Lakes area.

Usually towards the end of March, the ponds designed for carp culture are completely dried by draining the water into the adjacent lakes (Pl. 1, Fig. 2), while several of the shallow ponds dry up naturally during March. The ponds are then cleaned of debris and vegetation and the edges are trimmed. The mud exposed to the sun soon gets completely dried and is then broken up into dust. After these preliminary measures the ponds are filled up with water from the adjoining '*bheris*' towards the end of May or in June through small cuts, sometimes water is also introduced either with the help of a '*donga*' (Pl. 1, Figs. 3 and 4) which is a dug-out trunk of a palm tree or with a '*seoni*' (Pl. 1, Fig. 5), an improvized basket made of palmyra leaves or of tin sheets. The rains also start at this time. The tiny fry of carps are then introduced into these ponds, the number introduced depending on the size of the pond.

The introduction of fry in the Salt Lakes area (Pl. 1, Fig. 6) begins towards the end of May or in June and continues uptil July, while fingerlings are introduced during September and even in October. Heavy showers of rain within two days of the introduction of the tiny fry in the ponds, are believed to be detrimental to the life of the fish.

The rate of growth of carps is not uniform in all ponds. The young of the larger forms such as *Labeo rohita*, *Cirrhina mrigala*, *Catla catla*, etc., normally grows to $\frac{1}{4}$ seer in one year although instances of carps growing to $\frac{3}{4}$ of a seer in one year are not rare. 'Bhetki' also, according to Gupta (1908), grow to $\frac{1}{2}$ seer in the Salt Lake '*bheris*' in course of a year, that is to say, in the second year of introduction. The latter author further mentions that in Bavaria, the carps can attain a weight of 1 to 2 lb. in the second year. Both in America and Europe, carps are nurtured under adequate supervision and feeding is done scientifically, as against the empirical methods followed in this country.

The carps when sufficiently grown are disturbed by beating the water with bamboo poles, etc., as movements of fish in the ponds resulting from this disturbance are believed to result in rapid increase in size; growth to a size one seer or more in the course of two years has been noted as a result of such

treatment. During February and March one often notices fish being thus agitated in the Salt Lakes.

Food supply.—Food in the form of rotten water hyacinth, sullage water and algae is supplied to the fry. The hyacinth is first allowed to rot and then introduced in the ponds. The dried mud from bed of sullage canals is also used as food of the fish fry, as also the algae and other micro-organisms growing around grasses on edges of ponds. Some people in the absence of sullage water prefer the introduction of *Lemna* which is eagerly eaten by the fry (*vide* Chatterji, 1934). The food of carps as already pointed out by Gupta (1908) constitutes mostly of vegetable matter while the animal food consumed is composed of insect larvae, small crustacea and mollusca and other similar organisms (Mookerjee, 1938). Given the suitable food the minute fry will grow to a size of one to three inches within three months of introduction. Gupta (1908) noted carps growing to 16 or 17 cm. in length in the first year.

Great discrimination has to be exercised in supplying the food matter to the growing fish and if the food is not of the proper type the fry die. The favourite food of the minute fry consists of micro-plankton, such as Infusoria (*Paramoecium*, according to Chatterji, 1934), diatoms and minute unicellular algae, for the bigger fry or the fingerlings, minute crustaceans such as *Daphnia* and *Cyclops* in addition to algae, and for the fairly adult stage, earthworms, chironomid larva and higher crustaceans such as shrimps, in addition to microscopic forms like *Daphnia*, *Cyclops* and algae (*vide* Innes, 1932).

Mortality among the fry and fingerlings may be very high owing to congestion and lack of proper food. The distribution of young stages of carps from a rearing pond where congestion is noticeable to several ponds is useful as it ensures a better development of the fry. Another good practice often noticed in the areas in which fish are cultured is frequent dragging by nets. This helps in the removal of the slimy matter often of algal origin, and external parasites from the body of the fish. De (1910) mentions the practice of planting bamboo sticks and posts in the middle of the tanks to enable fish to rub off their external parasites. The agitation set up in the water column by the dragging of nets also helps in the partial removal of the gaseous formations from the substratum of the ponds. The mortality of fish is very heavy in foul water which is not properly aerated and bears an excessive amount of carbonic acid gas, or when the temperature of the water is high (Gupta, 1908; Sewell, 1926; Pruthi, 1932; Sen, 1939). The dragging of nets further ensures brisk movement which is highly beneficial for the healthy growth of the fish.

Some people allow soap water in their ponds which are found unfavourable for the growth of fish probably to increase the alkalinity of the water; this especially in acidic waters is

reported to have yielded good results. A similar practice of soaking plantain fellings, rich in alkali, in waters fouled by the stifling of jute, is followed in parts of East Bengal (Gupta, 1908).

Natural enemies of the fry.—The so-called eggs which are nothing but the tiny fry of the carps are preyed upon by the frogs *Rana tigrina*. Fish of the genera *Barbus* and *Ambassis* are also harmful to the fry of the carps, the former feeds voraciously on the food matter available in the ponds, while the latter may inflict injury to the fry by their sharp spines. Sometimes fry of certain carnivorous fish like *Wallagonia* are accidentally introduced into the ponds along with the fry of carps. This should be guarded against, otherwise there will be a great fall in the yield of carps. Thick growths of *Hydrilla* and *Ceratophyllum* hamper the normal development of the fish fry. Very little of such aquatic vegetation should be permitted to grow in the ponds where carps are being reared, and predator fish like *Ophicephalus*, *Notopterus* and *Wallagonia* should be removed as soon as they are detected in the ponds in order that the commercial species of carps can thrive (Chatterji, 1934; Hora and Mukerji, 1938).

In conclusion, I am grateful to Mr. K. N. Das of the Zoological Survey of India for his assistance in the identification of the fish recorded in this paper and in various other ways. Further, I am greatly indebted to Drs. B. Prashad and S. L. Hora for the many valuable suggestions I have received from them.

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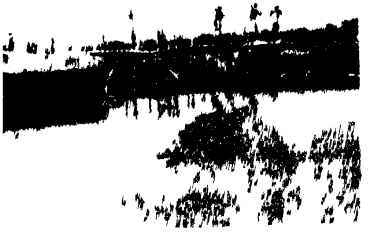
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1 Kristopur canal showing a cut to connect with the Salt Lake 'bheris'



FIG 2 A fish pond dried by drawing the water into the Salt Lakes

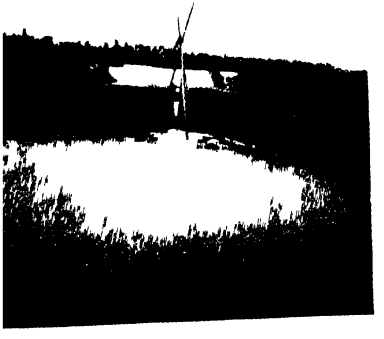


FIG 3 Donga utilized in introducing water into a pond for fishery

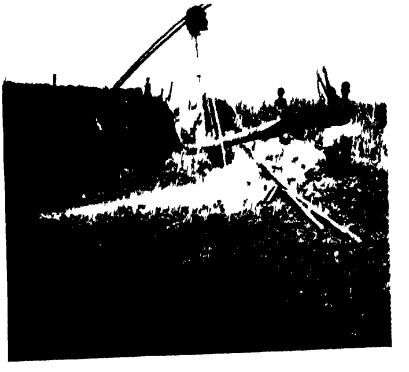


FIG 4 A closer view of a donga



FIG 5 'Seoni' used in bailing out water



FIG 6 A view of Salt Lake 'bheris'

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ARTICLE NO. 3.

Blood Groups among Balahis (weavers), Bhils, Korkus, and Mundas, with a note on Pardhis, and Aboriginal Blood Types.

By EILEEN W. E. MACFARLANE.[1]

A visit was made early in 1941 to the Nimar District in the Western Central Provinces, India, primarily to get more blood groups from the aboriginal Bhils. While biding my time to go to the Bhil villages, I was able to get a good sample of bloods from the Balahis at Khandwa and later some aboriginal Korkus and a few nomadic Pardhis were also grouped.

The methods used were the same as on previous trips and have been described (Macfarlane, 1940).

The *Balahis* are a lower caste of Hindu weavers, labourers, and servants of the Hoshangabad and Nimar Districts. The number of Balahis in the Central Provinces and Berar returned in the 1931 census was 56,782, and over half a million in India, chiefly in Rajputana and Central India. Although they are an 'impure' caste who cause pollution to caste Hindus, they rank above the lowest occupational castes of untouchables such as the Chamārs (leather workers) and Mehtars (scavengers) in the Hindu social scale.[2]

Their position is on a par with those of the large Mahār and Mang castes who are widespread in Western and Central India. According to their traditions they came to the Nimar from the north-east, and they are considered to be a branch of the Kori caste of weavers in the United Provinces (Russell). Russell (1916) mentions that in the Hoshangabad District they are known alternately as Mahārs and that the latter caste is also sometimes called Dher. In the Nimar the Balahis rank above Mahārs, and have no social dealings with them. Russell also records that some of the Balahi sub-castes and endogamous groups are called by the names of castes: Katia, Kori, Mahār, and Gannore, and that the latter is a Rajput clan of left-handed descent.

Physically the Balahis show a considerable amount of variation especially in colouration and nasal form. Their noses often have a convex bridge, as in Guha's Alpo-Dinaric type (Guha, 1937) and an occasional person with hazel or grey eyes

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[2] Lower than Balahis:—Chamārs, Mehtars, Basors, Mangs, Dhobis, Fermals (Father S. Fuchs private communication, June 1941).

occurs (figures 1 and 2). They take people into their caste from higher castes, such as an occasional outcaste upon his request, and adopt women who elope with a Balahi. According to Russell (1916) they admit Korkus and Gonds and any but the very lowest Hindu occupational castes. Father Fuchs, who has lived amongst them for some years, told me that in recent years only infrequently is an occasional individual thus taken in, usually a man who has become friendly with the Balahis through living with them, and no group as such has been received. Their culture shows some relics of a pre-Hindu religion now overlaid by the degenerate form of Hinduism which they profess (Fuchs, 1940). The Balahi sub-castes of the Nimar eat the flesh of cattle that have died. They claim to be the oldest inhabitants of the District (Russell) and this is confirmed by higher caste Hindus who know by tradition that their forefathers bought their fields from Balahis (Father Fuchs private communication, 1941).

After subtracting data belonging to members of the same immediate family, the blood group distribution was obtained from two hundred Balahis as shown in Table I.

The Balahi data are unusual for India, where there is characteristically a preponderance of Group B over Group A, especially in the lower castes, except in the south-west (Macfarlane, 1938). In the Balahis there is an equal distribution of the three main blood groups, a condition that has hitherto been found in this country only among the Mundas, and the related Maria Gonds far to the East, in the Mahrattas, Rajputs, Jats, and Pathans.[1] Because Balahis do not resemble the Munda-speaking tribes in general appearance and have not been linked with them by scholars, we may neglect the Mundas at present. Until more blood group data are available from Rajputana, the United Provinces and Bombay we cannot speculate on the resemblance in blood group distribution between the Balahis and the castes listed above from those regions. The Balahis have been in contact since the middle ages with the Rajputs who twice migrated over this part of India during the Moghul wars of the fourteenth century and earlier (Russell).

The contrast between their blood group distribution and that found in the Depressed Classes of the Deccan (Macfarlane, 1940) is surprising. In a small sample (75) of the latter people were found 18·7% Group A and 44% Group B and a similar condition exists among the lower castes of South Bengal (Macfarlane, 1938). Majumdar (1940) in 92 Chamars in the United Provinces found 13·3% Group A and 38·3% Group B. Some of the higher castes in the United Provinces also seem to have a marked preponderance of Group B over A (Majumdar). In

[1] For comparison of all samples see Boyd's Tables (1939) for original references, see also Macfarlane (1938).

Table II certain Indian races and tribes are listed with relation to the serological value of (A-B). The Balahi data seem to indicate that the ancestors of this caste originated chiefly from the north-west of their present habitat, since Indian groups possessing frequencies for both the genes A and B lying between 0·210 and 0·259 are the Balahis, Jats, Mundas, Rajputs, and Pathans only. The value 1·2 for D/σ (Table I) is not high enough to suggest genetic instability (Boyd). It would appear that any accessions to the Balahi caste in the past few generations have been genetically negligible. Serologically they are distinct from the depressed Mahārs and Dhers.

The *Bhils* of the Nimar are cultivators and tenant farmers inhabiting small scattered villages among the fields. They are descended from a war-like tribe of aboriginal hunters of the Vindhya, Satpura, and Ajanta Hills who caused a lot of trouble as freebooters during and after Moghul times. In the 1931 census 363,124 Bhils were returned from Central India and 30,325 from the C.P. and Berar. Their original Bhili speech was classified by Grierson (1906) as a Mundari language, but they have now given up their own dialect for Hindi. Centuries ago when the Rajputs came into the Bhil country the two peoples were closely associated for some generations, the Rajputs sometimes taking Bhil women for mates. This led to Hinduization and the disintegration of the tribe into separate endogamous groups based on the presence or lack of Rajput ancestors (Venkatachar). The Bhilallas are also descended from offspring of Rajput men and Bhil women (Russell).

Hinduized Bhils admit outsiders into the tribe from any communities except those of lower castes than themselves among which are Balahis and Nahals. Bhils and Balahis inhabited separate sections of the villages visited near Khandwa. In the last census it was reported that the Bhils were 'a very mixed lot'; a condition that was also confirmed by Dr. Guha for the Bhils that he measured in the Vindhya Hills (Guha, 1935). A marked variety of physical types was seen among the Hinduized Bhils whom I visited, but the prognathous, thick-lipped, often weak-chinned, platyrhine aboriginal type with high cheek bones, pronounced supra-orbital ridges and depressed root of the nose was infrequent. This is the type which Guha (1935, 1939) designated as *Nishadic* or Proto-Australoid, and its various facial characteristics seem to segregate out in individuals (see figures 7 and 8). None was seen with light coloured eyes.

If, as their blood group distribution indicates, the Balahis are closer to the more highly cultured folk living to the north-west of them, we have here an interesting example of a race more primitive physically and culturally—the Aboriginal Bhils—ranking higher in the Hindu socio-ritualistic scale than a people who are by descent more specialized or advanced in these respects—the Balahis. The degraded position of the latter is

perhaps partly due to their feeding habits, to their occupation of weaving (Russell) and also to the fact that they are a mixed caste with accretions from outcastes (Fr. Fuchs private communication).

Last year a few Hindu and Muslim Bhils from the Ajanta Hills were grouped in Hyderabad (Macfarlane, 1940) and an exceptionally high number, even for India, were found to belong to Group B. Khandwa was chosen to get more data because it is not far, about a hundred miles, from the Ajanta Hills. In 1939 Dr. W. Koppers took measurements and grouped bloods of Bhils in Jhabna State to the north and Korkus in Berar, but his data are not yet available. Father S. Fuchs was Dr. Koppers' assistant and I was fortunate to have his help in the Nimar.

The Hindu Nimar Bhils are friendly with the Christian missionaries who introduced me to them in some villages fifteen to twenty miles south-west of Khandwa. At first I was well received, but later their suspicions were aroused by some wise-acres at the weekly market, and I was unable to get the two hundred bloods as desired. After subtracting some close relatives data from 140 were left.

These Bhils also show a very high percentage of Group B and an unusually large amount of Group AB (Table I). The latter is indicative of heterogeneity. If Group AB people are taken into consideration then 58·8% of these Bhils possess agglutinogen B and 40% possess A. The Bhils in Hyderabad had Group B 52·3%, Group AB 2·3%. In all blood group samples for India of over one hundred available so far, only these Bhils, the Nimar Korkus and the Paniyans of South Malabar show a frequency for Group O (r) of under 0·50. The Paniyans have very little B. The fact that Guha (1935) found a definite association in CRL between the Bhils and the Chenchus is interesting because it suggests their possible relationship with the southern tribes of aborigines. The Chenchus resemble the Paniyans, alone among Indian tribes, in having a preponderance of Group A over Group B. If the Bhils are found to have southern affinities, this will further support the observation that as the southern aboriginal tribes migrated northwards they seem to have accumulated more of Group B, e.g. the Mālés and Oraons of Bihar (Macfarlane and Sarkar), see Table III. Excluding the Paniyans and Oraons, each of whom stand distinct serologically, there is seen to be relatively little variation in p (Table III), only 8%, between the four widely separated tribes Chenchu, Mālé, Korku and Bhil; whereas q increases among them 21% from south to north and east. The Chenchus and Mālés are Dravidian speaking, while both the Korkus and Bhils are believed to come from Mundari-speaking ancestors. The percentages of Groups B and AB in the Korkus and Bhils show some similarity with those found in the Todas of the Nilgiri Hills, South India, but the

latter have a lower frequency for the gene B, $q = 0{\cdot}278$, as well as for gene A, $p = {\cdot}157$, frequencies which are more like those found in the Santals, the non-caste Hindus of Bengal and the Depressed Classes of the Deccan. The racial affinities of the Todas are no doubt very mixed. They may have migrated to their present location from north central India, but there is nothing in their blood group distribution to support a Proto-Nordic descent. Their serological resemblance to other tribes in India is probably more significant than their resemblance to the Ainu in blood group distribution. (See Boyd's Tables 1939.)

The value for D/σ for these Bhils does not indicate a genetic instability, therefore the various racial elements in their blood group distribution have reached equilibrium. The high percentage of Group AB shows heretozygosity.

The *Korkus* are at present the westernmost tribe of those who speak a Mundari dialect (Grierson). At the time of the 1931 census there were 176,616 of them in the Central Provinces and Berar; 52,172 were returned for the Nimar District. They are believed (Russell) to be racially akin to other tribes in the Mundari-speaking group such as Baigas, Kols, Korwas, and Nahals of the C.P.; Mundas and Santals of Bihar. Their sept names are the same as those of the Kols (Russell). They will not eat with Gonds, but Gonds, also Mangs and other lower castes, accept food from them Physically many of them resemble Guha's Proto-Australoid type (figures 5 and 6).

Most Korkus are timid, suspicious of strangers and difficult to contact. I am indebted to another Christian missionary through whose good offices I received the co-operation of the village Patel at Kanapur (Thomog on old maps) who employs many Korkus from neighbouring villages as agricultural labourers. These villages are some fifteen miles east of Berhanpur near the Berar border. After subtracting some persons belonging to the same family 140 individual blood samples were left.

The Korku village is unlike anything I have yet seen in India. The low wattle and thatch huts are built in two continuous straight rows on either side of a very wide central street. There is a space between the walls of two houses, usually, only where a street crosses.

The Korku data show a close resemblance to those of the Bhils (Table I) with slightly more of A and less of B. The differences are not significant and the χ^2 test [1] for the two gives the values $\chi^2 = 1{\cdot}33$, $P = 0{\cdot}73$ (kindly calculated by Mr. S. S. Sarkar), which demonstrated that they are samples from a genetically undifferentiated population as far as blood groups are concerned.

[1] By the χ^2 test Todas and Korkus are also undifferentiated ($\chi^2 = 5{\cdot}85$, $P = 0{\cdot}12$) while Bhils and Todas are significantly differentiated ($\chi^2 = 15{\cdot}14$, $P = {\cdot}0017$) according to Mr. Sarkar's calculations.

As in the Bhil data the relatively high percentage of Group AB in Korkus shows some heterozygosity but the low value for D/σ indicates genetic stability for the blood groups at present. There are no published data of physical measurements from the Korkus but Dr. Koppers took some in Berar. In Nimar the Korkus speak Hindi, and have the status of a backward tribe under the Government. In the Hindu social scale the hinduized Korkus are on an equal footing with the Bhils. At Kanapur and elsewhere the Nahals, who are also of aboriginal stock (also classified as a backward tribe officially), do the lowest menial work as serfs of the Korkus. They were hunters and herb gatherers who have been exploited by the agricultural Korkus and are on the road to becoming a depressed, 'impure' caste. Hinduized Nahals rank a little higher than Balahis (Father Fuchs private communication).

Munda Blood Groups.

In October 1940 I obtained blood group data from 120 Mundas workers in the ore mines of south-east Bihar. They were from the Singbhum District, Bihar, and from the neighbouring Orissa States of Keonjhar and Mayurbhanj. This sample is therefore free from familial strains. The three main blood groups were found to be about equally distributed in these Mundas (Table I). Sarkar (1941) by applying the χ^2 test has found that these Munda data and his Santal data from the Santal Pergannas, Bihar, are samples from an undifferentiated population serologically. Among the Mundas and Santals 37% and 31% possess agglutinogen A respectively and 36·7% and 46% respectively carry B. The Korkus like the Bhils have an unusually high concentration of both agglutinogens, 42% of them have A and 52% have B. Isolation combined with differential fertility might produce the Korku type of blood group distribution, with excess of Group B, from a Munda-Santal type with equal amounts of A and B. If these Mundari-speaking people are another racial stock which entered India later than the southern aborigines, they have accumulated more of B as they proceeded west just as the southern tribes have as they came north (Macfarlane and Sarkar). The source of all this B is debatable. Statisticians have found that mutation is an unlikely source (Boyd, 1940) because the blood groups have no selective value and no indication of a high mutation rate has yet been discovered in family studies.

So far the only communities found in India with values for q of 0·26 and over are the Bhils, Korkus, Chamārs, Deccan Depressed Classes and several lower castes in south Bengal (Macfarlane, 1938). There may have existed an ancient stock in north central India, rich in B like the Oraons and like them a branch of the southern aborigines (Macfarlane and Sarkar)

which has been submerged nationally; now, degraded and exploited among the depressed classes, the race shows its effect in this dominant gene which seeps into every stock that comes to the Ganges Basin and central India.

In this way the Korkus and Bhils could be a product of a southern stock assimilated by the invading Mundari-speaking tribes who were later submerged themselves, to a large extent, by the Aryan-speaking invaders. Blood group studies therefore may give evidence for the existence of an older human stratum than those already recognized in this part of India.

The *Pardhis* are an aboriginal, nomadic tribe of hunters of central India. A band of Pardhis was awaiting trial at the jail at Khandwa and the authorities kindly allowed me to visit them for blood samples. There were only nineteen including a father and son (both Group B), three brothers (all Group O) and two brothers (both Group B). If only one member of a family is included that leaves fifteen bloods which were distributed thus: Group O—6, Group A—4, Group B—4, Group AB—1. This indicates that the Pardhis are well supplied with both agglutinogens. All the men had dark brown eyes and very dark skins, but they showed considerable structural variation and included pronounced aboriginal types (figure 4) as well as some who resembled the type Guha (1937) designates as the Indus or Mediterranean type (figure 3). Similar variations in racial type were recorded in the Todas by Cipriani.

Blood Types in Mundas and Bhils.

Only a small quantity of anti-M and anti-N test fluids were available. Since there are no data for blood types among Indian aborigines 65 Mundas in the Singbhum District, Bihar, were tested with anti-N and 57 Bhils in the Nimar, C.P., were tested with anti-M. The values for the frequencies m and n of the two genes were calculated from the formulae $n = \sqrt{N}$, $m = \sqrt{M}$ (Boyd, 1939) and are given in Table IV together with the percentages of the three types. These inadequate data indicate that these tribes possess less of M and more of N than the general population of Bengal (Greval, Macfarlane, 1939). It is interesting that the Mundas, who physically show fewer signs of racial intermixture (Macfarlane and Sarkar), have more N than the Bhils. Values for n of over 0·50 are listed by Boyd (1939) in peoples to the east of India only for the Ainu, Indonesians, Javanese, Sudanese and Australians. Blood type N seems to predominate more in the primitive races and early inhabitants.

Summary.

1. The Balahis, lower caste weavers of the Nimar District, C.P., show more relationship, serologically, with the Mahrattas,

Rajputs, Jats, and Pathans west and north of them than with the Depressed Classes. They have the three main blood groups in equal proportions with a little more of Group A than of Group B.

2. The Bhils have high percentages of groups B and AB and the highest frequency for gene B yet found in India. The Korkus and Bhils are very similar in blood group distribution and seem to belong to an undifferentiated population.

3. There is some resemblance between the Korku and the Toda blood group distributions. It is suggested that the Korkus and Bhils, even if descended from Mundari-speaking ancestry may also have ancient affinities with the southern aborigines (Chenchus and Paniyans) from whom they differ serologically chiefly in possessing more B.

4. The Mundas of the Singbhum District, Bihar, show the three main blood groups equally distributed, but they do not differ significantly serologically from the Santals who have more of B.

5. As the Mundari-speaking tribes migrated westward in India, they accumulated more of Group B, perhaps from an aboriginal people with southern affinities whose descendants now are represented in the Depressed Classes.

6. A few of the nomadic aboriginal Pardhis showed all three blood groups present and a marked variation in racial types.

7. Mundas and Bhils, in small samples, each show less of type M and more of type N than the general population of Bengal.

Acknowledgments.

These investigations were made possible through a grant-in-aid from the Royal Society, London. I am also indebted to the friends, missionaries, and local officials who gave valuable help, particularly to Father S. Fuchs, S.V.D., for help and criticism.

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TABLE I.

The distribution of blood groups in three Nimar castes and in Mundas of South Bihar.

People.	No.	Nos. and Percentages in Groups.				Frequencies.			D/σ
		O	A	B	AB	*p*	*q*	*r*	
Balahis	200	61 *30·5*	64 *32·0*	60 *30·0*	15 *7·50*	·222	·209	·552	1·2
Bhils ..	140	26 *18·57*	33 *23·57*	58 *41·43*	23 *16·43*	·218	·344	·431	0·3
Korkus	140	28 *20·0*	40 *28·57*	53 *37·86*	19 *13·57*	·250	·313	·447	0·4
Mundas	120	40 *33·33*	36 *30·0*	45 *29·17*	9 *7·50*	·219	·214	·577	0·6

TABLE II.

Serological value A–B of Mundas, Nimar castes and related peoples, in ascending order.

Race or Caste.	(A–B)	Race or Caste.	(A–B)
*Todas .	− 18·5	Mahrattas ..	− 7·2
*Bhils	− 17·8	Rajputs ..	− 5·0
*Santals ..	− 13·9	Pathans ..	− 2·0
Jats .. .	− 11·0	*Mundas ..	− 0·8
*Korkus .	− 9·3	Baluchs ..	0·0
*Maria Gonds ..	− 8·1	Balahis ..	+ 2·0

* Aboriginal Tribes.

TABLE III.

Blood Group gene frequencies in some southern and Nimar aborigines compared, in ascending order of q.

Tribe.	*p*	*q*	*r*
Paniyan ..	·461	·078	·447
Chenchu ..	·252	·133	·608
Mâlé ..	·167	·181	·649
Oraon ..	·088	·219	·686
Toda .	·157	·278	·545
Korku	·250	·313	·447
Bhil .	·218	·344	·431

TABLE IV.

Blood Types and their frequencies in Mundas and Bhils.

Tribe.	No.	Percentage in Types.			Frequencies.	
		M	MN	N	*m*	*n*
Munda ..	73	23·29	49·99	26·73	48·3	51·7
Bhil	57	31·4	49·23	19·30	56·1	43·9



FIG 1. Balahi girl



FIG 2 Profile of 1



FIG 3 Pardhi man



FIG 4 Pardhi boy



FIG. 5 Korku man



FIG 6 Profile of 5



FIG 7. Bhil man



FIG 8. Profile of 7.

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ARTICLE No. 4.

Observations on an intestinal flagellate, *Tetratrichomastix hegneri*, sp. nov., from the 'skipping frog' *Rana limnocharis* Meig.

By P. L. MISRA.

(*Communicated by Dr. K. N. Bahl.*)

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INTRODUCTION.

During my short stay at the Protozoological section of the Imperial Veterinary Research Institute, Mukteswar-Kumaun in March 1940, I examined half a dozen specimens of the 'skipping frog' *Rana limnocharis* Meig.[1] for protozoan parasites in their guts. Besides Coccidia, *Entamoeba*, trichomonad flagellates and ciliates, I found a flagellate, which showed the characters of the genus *Tetratrichomastix* Young, 1935, in the posterior part of the intestine and rectum in two out of six specimens. This flagellate is the first of its kind to be recorded from India and second of its type to be described from a vertebrate host. I give below a morphological account of this organism which I have named *Tetratrichomastix hegneri*, sp. nov., after Prof. R. Hegner of John Hopkins University, who has made valuable contributions to our knowledge of the trichomonad flagellates.

MATERIAL AND METHODS.

The frogs were collected from a small pond at a height of about 6,000 ft. in the lower Himalayan range, about 4 miles away from the Mukteswar Institute. Fresh cover-glass preparations of the gut-contents, either as such or diluted with a little normal saline, were made and these flagellates along with

[1] The frogs were identified at the Indian Museum through the kind courtesy of Dr. S. L. Hora.

other protozoa occurring in association were examined in the living condition. Intra-vitam staining with neutral red was also employed to study the movement of the organisms in the living condition. Air-dried films of the gut-contents were fixed in acetone-free methyl alcohol and stained with dilute Giemsa to ascertain the number of flagella. For other structures, wet smears were fixed in hot sublimate-alcohol or Bouin's fluid and stained with iron-alum haematoxylin after the method of Heidenhain.

Observations on *Tetratrichomastix hegneri*, sp. nov.

The flagellates show characteristic jerky movements when examined in fresh condition. This type of movement at once reminds that of *Monocercomonas bufonis* Dobell (1908, 1909), or *Eutrichomastix* (*Trichomastix*)[1] *batrachorum* Dobell (1909), and, is perhaps due to the fact that the anterior flagella beat backwards in unison. The posteriorly directed flagellum also vibrates rapidly but it does not extend forwards up to more than three-fourths of the body from the posterior end during its lashing movements. It was impossible to count the number of flagella in the living condition, as the organisms are exceedingly active. Intra-cytoplasmic portion of the axostyle was not visible in the living condition, but its free portion, which is flexible and bends during movement, was often visible. To this free axostylar portion are attached minute particles of débris; whether this attachment is due to some axostylar secretion is difficult to ascertain. Occasionally, it was noted that certain individuals remained attached to the mass of débris by their free axostylar ends and could not free themselves. The cytostome is undetectable and the nucleus is also indistinct in the living condition.

In appropriately fixed and stained preparations, the body appears to be irregularly pyriform, with its one side more convex than the other. The periplast is distinct. At the anterior end there often appears a cleft or groove situated on the more convex border of this end and this represents the cytostome of the organism (Pl. 3, fig. 1), while on its left there is a dent at its anterior extremity through which all the flagella appear to come out (Pl. 3, fig. 2). The presence of this groove affects the symmetry of the organism which is approximately bilateral. The four anterior flagella usually adhere together and can be made out only by counting their free extremities. Specimens with well-spread-out flagella were also encountered and it was from these that one could make out the four anterior flagella which were equal in length and slightly longer than the body. All the five

[1] The generic name *Trichomastix* was pre-occupied by an insect, hence Kofoid and Swezy (1915) introduced the name *Eutrichomastix* as a substitute for it.

flagella arise from a single basal granule which normally remains apart from the nucleus though in certain specimens it was seen attached to the nuclear membrane (Pl. 3, fig. 3): this latter condition is caused, in all probability, by shrinkage of specimens during the preparations of smears. The basal granule stains deep-pink with Giemsa and black with iron-alum haematoxylin. There is no rhyzostyle. The axostyle originates distinctly from the basal granule and during its course towards the posterior end bends round the nucleus but never pierces it. The axostyle consists of a deeply staining fibre or rod (Achsenstab) which stains pink with Giemsa. In haematoxylin-stained specimens it assumes a deep tint while in certain cases it presents a hyaline appearance with minute granules inside it (Pl. 3, fig. 4). The free portion of the axostyle is elongated and has a pointed end; in certain specimens it seems to be curved. There is no protoplasmic sheath around the free portion of the axostyle.

The anteriorly located nucleus is spherical or slightly ovoid in shape and has a thin nuclear membrane and a centrally placed endosome, surrounded by a faintly staining homogeneous area.

The cytoplasm is vacuolated and contains inclusions chiefly of bacterial nature. In a few specimens the cytoplasm was seen to contain coccus-like bodies, which probably belong to the genus *Sphaerita* (Pl. 3, figs. 4 and 6).

Although very few stages showing multiplication were seen but multiplication seems to take place by longitudinal fission. The basal granule divides into two daughter granules which move apart, one bearing two flagella and the other three (Pl. 3, fig. 5). It appears, therefore, that in subsequent stages three new flagella on one side and two new ones on the other develop from the daughter basal granules thus making five flagella for each daughter individual. Meanwhile, the nucleus divides into two and this division is followed by a longitudinal cleft at the anterior portion of the body, which deepens and divides the organism into two daughter individuals.

Encystment: The body of the flagellate becomes rounded (Pl. 3, fig. 6) and the flagella are lost,[1] but the basal granule persists (Pl. 3, fig. 7). At first a thin cyst-wall is secreted and in earlier stages the nucleus with its endosome is quite distinct, but the cyst-wall thickens later, and the basal granule divides into two parts which separate, move away from each other, and come to lie on the opposite sides of the spherical cyst. Between these two daughter granules extends a centrodesmose (Pl. 3, fig. 8).

[1] Mackinnon (1915) has given a series of sketches of the encystment of a trichomastigine, *Eutrichomastix* (*Trichomastix*) *trichopterorum* or *Tetratrichomastix parisii* (?), and has described that the flagella adhere to the body while rounding takes place and persist in fully formed cysts. I could not, however, detect the adherence of the flagella or their persistence in the cysts.

The cytoplasm of the cyst is clear. Further stages of division were not available.

Measurements:—

(*a*) Length of the body exclusive of the free axostylar portion 5·6μ–10·3μ; average for 50 specimens 7·8μ.

(*b*) Width of the body at maximum diameter 2·8μ–5·6μ; average for 50 specimens 4·6μ.

(*c*) Length of the free axostylar portion 1·5μ–4·2μ; average for 50 specimens 3·2μ.

(*d*) Diameter of the nucleus 1·4μ–2·7μ; average for 50 specimens 2·3μ.

(*e*) Cysts 4·8μ–6·3μ.

Previous work.

Mackinnon (1913) instituted the new sub-genus *Tetratrichomastix*, and described *T. parisii* as the type species of this sub-genus, which possesses an 'axostyle and five free flagella, four anteriorly, and one posteriorly directed'. *T. parisii* was found in the intestine of the grub of *Tipula*. In a later communication (1915) she described spherical cysts, 4-5μ in diameter, of a trichomastigine, but she was not sure whether these cysts belonged to *Eutrichomastix* (*Trichomastix*) *trichopterorum* or *T. parisii*. Becker (1926) described *T. citelli* from the caecum of the ground-squirrel *Citellus tridecemlineatus*. He regards *Tetratrichomastix*, without giving any reason, to be a 'sub-genus of *Eutrichomastix*'. Young (1935) raised the sub-genus *Tetratrichomastix* to the generic rank on the ground that 'The number of flagella is an important morphological feature, and since *Eutrichomastix* possesses three anterior flagella and the sub-genus *Tetratrichomastix* four anterior flagella, it seems desirable to raise the latter to the generic rank'. He described *T. blattidarum* from the posterior part of the intestine of different species of cockroaches, namely, *Blatella germanica*, *Blatta orientalis* and *Periplaneta americana*, and could successfully cultivate this organism in haemoglobin-saline medium. Kowalczyk (1938) described *T. mackinnoni* from the intestine of the larva of the Japanese beetle, *Popillia japonica*. These are the only reports, so far as I am aware, of the species of this genus recorded up to date.[1]

[1] Sangiorgi (1917) cultivated a flagellate from human faeces and named it *Tetratricomastix intestinalis*. But this flagellate had only four flagella (not five) and has been regarded by Dobell and O'Connor (1921) to be 'at all events, probably a coprozoic species of *Tetramitus* and not an intestinal flagellate'. Hence, Sangiorgi's flagellate is simply a misnomer and has nothing to do with the genus *Tetratrichomastix*.

During recent years, much attention has been paid to the study of trichomonad flagellates in order to find out the most reliable characters for classifying these organisms, but there is still little agreement on this point. Certain authors, as for example, Parisi (1910) and Young (1935), attach much importance to the flagellar apparatus only. Thus Parisi believes that the number and mode of attachment of the flagella are real points of systematic value, and on this basis he has resolved the genus *Trichomonas* Donné into three sub-genera, namely (*a*) *Trichomonas, sensu strictu*, with three anterior flagella and an undulating membrane, (*b*) *Tetratrichomonas* with four anterior flagella and a trailing flagellum, and (*c*) *Trichomastix*[1] with three anterior flagella and a trailing flagellum, without an undulating membrane. Mackinnon (1913) made a further addition to this list by describing the sub-genus, (*d*) *Tetratrichomastix*, which, according to her, bears exactly the same relation to *Eutrichomastix* (*Trichomastix*) as *Tetratrichomonas* does to *Trichomonas*.

Contrary to Parisi's suggestion, there are other authors who hold that the flagellar apparatus is not of paramount importance in classification. Thus, Doflein (1916) believed that *Trichomonas* and *Eutrichomastix* are varieties of the same form: in the former the trailing flagellum remains attached to the body forming an undulating membrane, while in the latter it is cleft apart forming the 'schleppgeissel'. Doflein's view is shared by Prowazek (1904), Dobell (1909), Martin and Robertson (1911), Reichenow (1918, 1920), Chatton (1920) and others, though other workers, for instance, Wenyon (1926), Bishop (1931), Das Gupta (1935, 1936), and also Dobell (1907) hold that *Eutrichomastix* is a distinct genus;[2] the latter group of workers thus regard the flagellar apparatus to be of diagnostic value.

Alexeieff (1911) gives five characters, viz., (1) the condition of the undulating membrane, (2) the dimensions of the axostyle, (3) the distribution of the extra-nuclear siderophilic granules, (4) the structure of the nucleus, and (5) the presence and form of the parabasal body, which when applied to the study of adult forms should form a reliable basis for classifying the species of *Trichomonas*. Mackinnon (1913) expresses her scepticism with regard to the characters laid down by Alexeieff as they are liable to fluctuation, particularly in those forms which happen to parasitize more than one kind of host. Further, she writes, 'it is by no means always easy to decide which is the typical adult form'. In support of her arguments she has referred to the case of *Eutrichomastix* (*Trichomastix*) and has asserted that 'two of the said characters, i.e. the parabasal body

[1] *Eutrichomastix—vide* foot-note, p. 2, p. 28.

[2] My observations on the intestinal flagellates of *Varanus monitor* (paper in preparation) also lead me to believe that *Eutrichomastix* is a separate genus.

and the condition of the undulating membrane, are necessarily absent, and this renders the species determination on morphological grounds increasingly uncertain'. Moreover, she has laid stress on the degree of the intensity of staining, which may give a false conspectus of the form under observation, and may lead a worker to regard it as belonging to a different species. For instance, she could distinguish two forms of *T. parisii*, viz., (*a*) with a darkly staining nucleus, which is compact and rich in chromatin blocks and is often surrounded by a halo of small, siderophilous, bodies (ingested bacteria?), and (*b*) with a relatively large, faintly staining nucleus, poor in chromatin masses and with much vacuolated cytoplasm staining relatively intensely. Although these forms never occurred side by side in the same preparation she has refrained from designating them as different species and is 'strongly of the opinion that the degree of intensity of the staining must be taken into account'. Personally, I am of opinion that besides the morphological characters as defined by Alexeieff, and the intensity of staining reactions (as suggested by Mackinnon), the nature of the flagellar apparatus and its relations with the nucleus are the most valuable criteria for the classification of trichomonad flagellates, and in this I agree with the suggestion of Parisi and Young.

Systematic position.[1]

The presence of five flagella, four directed anteriorly and one posteriorly, and the absence of an undulating membrane at once determine the position of this flagellate as belonging to the genus *Tetratrichomastix* Young, 1935. In the shape and apparent bilateral symmetry of the body, and in the length of the free portion of the axostyle, *Tetratrichomastix hegneri* resembles *T. citelli* Becker, 1926, but differs from the latter in several characters; for example, in *T. citelli* the basal granule is attached to the nuclear membrane, the axostyle traverses the nucleus, the posteriorly directed flagellum and the anteriorly directed flagella are smaller in size as compared with the body length and the cytoplasm is less vacuolated (see Becker's figs. 16 and 18), whereas in *T. hegneri* the basal granule normally remains apart from the nuclear membrane, the axostyle never traverses the nucleus, the trailing flagellum and the anteriorly directed flagella are proportionately longer than the body and the cytoplasm is comparatively more vacuolated. In the length of its body, in the proportion of the lengths of the flagella as compared to the body-length and in the nature of its cytoplasm *T. hegneri* approximates *T. mackinnoni* Kowalczyk, 1938, but differs from the latter in the structure of the nucleus (in *T. mackinnoni* there

[1] Most of the descriptions given by the respective authors are very meagre, hence comparison has been made through their drawings.

is no endosome or endobasal body), in the relation of the basal granule to the nucleus (in *T. mackinnoni* the basal granule remains attached to the nuclear membrane), in the presence of a distinct periplast, and in the absence of a protoplasmic sheath round the free portion of the axostyle. In the structure of the nucleus mostly, in its relation to the basal granule, in proportion of the lengths of the flagella as compared to the body-length and in the nature of the cytoplasm, *T. hegneri* resembles *T. blattidarum* Young, 1935, but the latter differs from the former in the presence of a poorly developed axial fibre, measurements of the body and in the presence of two basal granules, from one of which arise the two anterior flagella and from the other arises the trailing flagellum along with the next two anterior flagella, as is evident from Young's single figure. *T. hegneri* differs also from *T. parisii* Mackinnon, 1913, in its shape, which in the latter is broadly pyriform or globular, in the structure of the nucleus (*vide supra*), in measurements of the body, and in the nature of the axostyle, which is poorly developed and is enclosed in a protoplasmic sheath, as is evident from Mackinnon's figures 30, 31, 32. Moreover, from her figures 30 and 32 it can be easily made out that there are two basal granules, from one of which arise the four anteriorly directed flagella and from the other arises the 'schleppgeissel', and in this respect also *T. hegneri* differs from *T. parisii*. In the light of these facts I consider *T. hegneri* to be a new species of the genus *Tetratrichomastix*.

The table on p. 33 shows the measurements, habitat, host, locality, etc., of the various species of *Tetratrichomastix*.

Summary.

(1) The genus *Tetratrichomastix* is recorded for the first time from India, and a detailed account of *T. hegneri*, sp. nov., is given.

(2) *Tetratrichomastix hegneri*, sp. nov., is the second species of this genus to be recorded from a vertebrate host, the first being *T. citelli* Becker, 1926, from the ground-squirrel *Citellus tridecemlineatus*.

(3) A comparison of the hitherto known species of *Tetratrichomastix* is appended in a tabular form.

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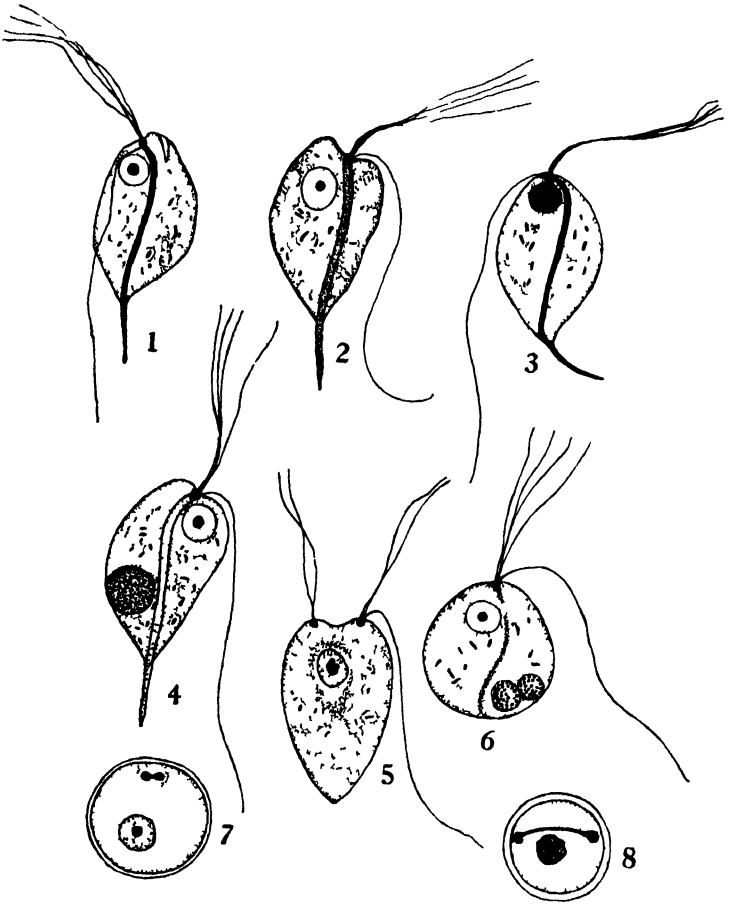
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TABLE.

Name.	Length of the body exclusive of free axostylar portion.	Nature of axostyle and length of free axostylar portion.	Width of the body.	Shape and size of the nucleus.	Cytostome.	Cyst.	Habitat.	Host.	Locality.
T. parisii Mackinnon, 1913.	8μ–12μ.	Poorly developed; measurement not given.	4μ–7μ.	Round or oval; measurement not given.	Not visible.	4μ–5μ.	Intestine.	Tipulid larvae.	England.
T. citelli Becker, 1926.	7μ–13μ.	Distinct; 2μ–4μ.		Round.	Indistinctly seen.		Caecum.	*Citellus tridecemlineatus.*	N. America.
T. blattidarum Young, 1935.	8μ–14μ; avg. 9μ.	Slender; 1·5μ–3μ; avg. 2μ.	4μ–8μ; avg. 5·5μ.	Round.			Posterior part of intestine.	*Blatta orientalis; Blatella germanica; Periplaneta americana.*	N. America.
T. mackinnoni Kowalczyk, 1938.	5μ–10μ; avg. 7·2μ.	Well-developed; 1/2–1/3 of body-length.	4μ–9μ; avg. 5·7μ.	Round.	Visible.		Intestine.	*Popillia japonica.*	N. America.
T. hegneri, sp. nov.	5·6μ–10·3μ; avg. 7·8μ.	Well-developed; 1·5μ–4·2μ; avg. 3·2μ.	2·8μ–5·6μ; avg. 4·6μ.	Spherical or slightly ovoidal. 1·4μ–2·7μ; avg. 2·3μ.	Visible.	4·8μ–6·3μ.	Intestine and rectum.	*Rana limnocharis.*	Mukteswar-Kumaun, U.P., India.



(All *Camera lucida* drawings drawn to scale *ca* 1400)

Tetratrichomastix hegneri, sp nov

Figs 1, 2, 3 and 4 show trophozoites fig 3 a trophozoite stained with Giemsa, fig 4, an individual invaded by *Sphaerita* fig 5 shows a dividing individual, fig 6, a rounded individual with two specimens of *Sphaerita*, figs 7 and 8, cysts.

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ARTICLE No. 5.

Racial Affiliation of the Gonds of the Central Provinces.

By D. N. MAJUMDAR.

The Gonds of the Central Provinces are an interesting people. Culturally they are superior to the wild tribes of India that live in the secure asylums of hills and fastnesses. They have from very early times come in contact with other racial groups, yet they have more or less maintained their cultural integrity. The record of their achievements forms the theme of their folk songs which are still sung in the fields and farms of Chattisgarh, in the Gond villages, that are scattered all over the central belt of India. The power and influence they wielded during the medieval period of Indian history survive still in various parts of the Gond country as not a few of the smaller states in these parts are ruled by families of Gond extraction.

The Gonds have been taken by some scholars as the true autochthones of peninsular India. Some have affiliated them with the pre-Dravidians of the south, while others trace them to a short long and moderately high headed type of aborigines with flat nose and thick lips. In an able survey of migrations of castes and tribes into Central India, Mr. C. S. Venkatachar discusses the problem of the Gonds (Census Report of India, 1931, Vol. I, pt. III, B, pages 60–68). 'The latter', according to him, 'may be the pre-Dravidians of the south on whom the Dravidians have imposed their language and due to some causes in the regions of north-east Madras, there must have been a large scale displacement of the tribes into the interior of the central regions.' The pre-Dravidians of which Mr. Venkatachar speaks in this connection (ibid., p. 61) are 'a dark Negroid race of low culture characterized by a physical type of very short stature, low forehead and flat face and nose'. There has been of late some support in favour of a Negrito substratum in India. Dr. B. S. Guha has drawn attention to the existence of a Negrito substratum in India (Nature, May 19, 1928, and June 22, 1929). Dr. J. H. Hutton has gone a step further, for he says, 'In any case the Negrito seems to have been the first inhabitant of south-eastern Asia. As already indicated, traces of this stock are still to be seen in some of the forest tribes of the higher hills of the extreme south of India' and similar traces, he argues, 'exists in the inaccessible areas between Assam, Burma and elsewhere' (Man In India, Vol. VII, 257–62). Dr. Eickstead does not admit the existence of the Negritoes in India (Die Rassengeschichte von Indien mit besonderer Berucksichtigung von Mysore, Zeits. Morph. Anthropol. Bd. 32, pages 77–124, 1933) and Dr. G. M. Morant has provided some statistical evidence to show that

they had little to do with the composition of Indian races. (Morant, G. M., A Contribution to the Physical Anthropology of the Swat and Hunza Valleys, J.R.A.I., Vol. LXVI, Jan.–June, 1936).[1] Whether there was or was not a Negrito race in India is not very material to our discussion as the Gonds do not possess Negrito features.

The aboriginal population of India discloses four types according to Dr. B. S. Guha (Census Report of India, Vol. I, pt. III, A, pp. LXII–LXIII). A short long and moderately high headed strain with often strongly marked brow ridges broad short face, the mouth slightly inclined forwards and small flat nose with the alae extended (1). A dark pigmy strain having spirally curved hair, remnants of which are still found among the Kadars and the Pulayans of the Perambicullan Hills (2). A brachycephalic Mongolian type constituting to-day, the main component of Assam and North Burma (3). A second Mongoloid strain characterized by medium stature high head and medium nose but exhibiting like (3) the typical Mongoloid characteristics of the face and the eye. This element constitutes the major strain in the population of the hills and not inconsiderably of that of the Brahmaputra valley (4).

The first of these types according to Dr. Guha is predominant among the aboriginal population of central and southern India and also have penetrated into the lower strata of the Indian caste groups. The Gonds do not wholly answer to the aboriginal type described by Dr. Guha as there are among the Gonds an appreciable number of individuals with short stature, long heads comparatively high cranial vault, faintly marked supraorbital ridges, broad short but orthognathous face with medium lips, prominent and long nose with the alae moderately spread, complexion varying from light brown to dark tawny brown, dark brown eyes and black straight or wavy hair. This type represents the bulk of the population of the peninsular and considerable portion of northern India. At one extreme this type has mixed with a lighter but dolichocephalic type in the north, and in the south, with the aboriginal type so that the various tribes and groups upper and lower in the south as well as in the north represent to-day mixed ethnic groups. The Gonds as suggested by their physical features are a mixed people. There is no Mongoloid traits among the Gonds though from cultural similarities Dr. J. H. Hutton thinks there are. (Dr. J. H. Hutton's Introduction to W. V. Grigson's Maria Gonds of Bastar).

In an earlier paper (Presidential Address, Anthropology Section of the Indian Science Congress, 1939) I compared the somatic characters of the various cultural groups in Bastar

[1] In the paper mentioned by the author, no statistical or other evidence is provided by Dr. Morant against the existence of a Negrito racial strain in India. Ed.

State of the Eastern States' Agency, and pointed out the intra-group racial variability within the State. Since then the statistical data were worked out by me in greater detail and I feel justified in presenting the results is a systematic way.

Bastar is a large State with an area of 13,725 square miles, lying between 17° 46′ to 20° 14′ N and 80° 15′ and 82° 1′ E. To the north of Bastar lie the Kankar State and the Dhamtari Tahsil of Raipur district, to the east is situated the State of Jeypore also under the Eastern States' Agency. The Godavari river forms the part of the southern boundary of the State and the Chanda district lies to the west. The central and north-western part of the State is rugged and mountainous. A plateau with an elevation of approximately, 2,000 ft. above sea level lies to the eastern part of the State running from north to south. Jagdalpur the capital of the State lies to the south of the plateau. The Indravati river which joins the Godavari after forming the southern boundary of the State, flows across the centre of the State from east to west thus partitioning it into two portions. The north-western is covered by a mass of rugged hills known as Abujmarh which affords shelter to the most primitive but the most attractive section of the population, viz. the Maria Gonds.

The ruling family of Bastar belongs to a Kshatriya clan. The founder of the family was one Annam Deo who belonged to the royal family of Warrangal. On the advice of his tutelary goddess he fled from Warrangal to escape the pursuit of the Mahomedan invaders. After traversing a long trek through the inaccessible areas followed by a mysterious jingle of bangles supposed to be the direction of the goddess who had instructed him through a dream not to stop unless the jingle disappeared and not to look backward so long the sound was audible, suddenly stopped on the other side of the Pairi river. The jingle of the bangles was silenced on account of noise caused by the wading of his followers through the water bed of the river and Annam Deo looked backward in suspense. The sound now finally disappeared and the river to-day forms the boundary between Kankar and Bastar States. The hereditary high priest of the temple accompanied him, so also some representative Rajput families and their camp followers. With them also was brought the sword of Dhanteswari which in the new shrine dedicated to her in Bastar provides the symbol of the goddess and even to-day the sword is worshipped in the Dhanteswari temple in Jagdalpur.

The native population of the State mostly belong to the Gond group of tribes and the immigrants and foreigners who have settled down in the area appear to have freely intermixed with the indigenes. The total Gond population in India according to the census of 1891 was 1,666,764. Since 1901 and up to the 1921 census the figures of Marias, Murias, Bhattras and

Parjas were included with Gonds, yet the strength of the Gonds was only 1,714,894. According to the census of 1931, the Marias number 181,095 so that if we deduct only the figures of Marias from the total for Gonds the latter do not show any increase in numerical strength. In the Central Provinces States the number of Gonds in 1911 were 578,752. It declined to 394,685 in 1921 and still went down to 369,303 in 1931. Thus the Gonds are showing a tendency to decline numerically. The population of Bastar State, according to the census of 1931, is 524,721 (263,248 males and 261,473 females), and those following tribal religions number 3,61,920 of which 181,390 are males and 180,530 females. The vital statistics of the State show that the population of the State is increasing by 5,000 every year.

Of the native population following tribal religions the Hill Marias are the wildest of the tribes in Bastar who are also enumerated in adjoining districts, in Vizagapatam and Hyderabad where they are known as the Koyas The Hill Marias do not seem to have entered the social economy or adopted the culture pattern of Bastar. They are still accustomed to their nomadic life in the hills and jungles and supplement their gleanings in the forests by shifting cultivation called *Dippa* and *Penda* in these parts. The Bison-horn Marias have settled down on the plateau and the plains and have been more influenced by their contacts with the higher castes in the State than their wild brethren the Marias of Abujmarh. The Murias of Kondagaon and those of Narayanpur also known as Jhorias are more advanced than the Marias. They have left their forest life long ago and their occupation of the plains and the plateau has brought them in closer contacts with the immigrants and foreign elements in the population of Bastar. The Murias of Kondagaon who are scattered on either sides of arterial roads, have developed an extremely efficient social organization among them and the dormitory institution with its complicated code of rites and rituals, its elaborate system of rules and regulations serve to maintain the tribal solidarity and integrity which would otherwise have been exposed to the disintegrating influences that usually result from such contacts. The two sections of the Murias, viz., the Kondagaon Murias and the Narayanpur Murias, the latter called Jhooriyas by Glasfurd and Jhoria by Grigson, are not different in physical features though in culture, the Narayanpur Murias seem to be more Hinduized and advanced than the Kondagaon Murias. The latter live on the plateau and on the hills and their dormitory institution is more integrated than that of the Narayanpur Murias.

Besides the Marias and Murias, there are also other important cultural groups in Bastar. The Dhruvas otherwise known as Parjas (a generic name which includes a number of tribal groups speaking Oriya but originally belonging to one or other of the tribal groups living in Bastar and the neighbouring areas)

claim a higher social status than the tribes already enumerated. They have adopted the dialect of a superior cultural group and also some of the important traits characteristic of the latter. The Bhatras are a little higher in social scale than the Parjas. They have a few subgroups which claim distinct social status as a result of Hinduization. The Hinduized Bhatras put on sacred threads and consider those who still adhere to tribal prescriptions as inferior and thus have already closed their ranks to other tribes and groups. To-day, Bhatras who still intermarry with other groups have distinct lower social status. Both the Parjas and Bhatras live by permanent cultivation. The Parjas appear to have come earlier to Bastar than the Bhatras, as they provide the priests in Bhatra villages.

The Halbas appear to be culturally a dominant group as the language of the State is Halbi and the supposed military antecedents of the Halbas give them an importance which is reflected in their attitude to the other social groups. They have mixed with the tribal groups and even to-day mixed marriages between Halbas and the other Gond tribes have not been tabued. The Dhakars are certainly superior to the Halbas and are reputed to be descendants of Kshattriya families who followed the ruling family to Bastar but it appears that they too have not escaped infusion of aboriginal blood as is evident from the practice of widow remarriage and that of *Ghaita Pani* or the auction of widows by the State authorities to rehabilitate Dhakar families originally meant to provide a *jus connubii* for them.

Although the language of the State is Halbi which is a mixed dialect of Hindi, Oriya and Marhatti and is akin to Chattisgarhi which is spoken over wide areas in the Central Provinces, the inhabitants speak the various dialects of the Gondi language. The linguistic map of Bastar will show the zones into which the State may be roughly divided. In the northern border of the State, Chattisgarhi Hindi is spoken. The greater part of the eastern border has Oriya as its principal language. In the south-east some islands of Koya dialects are found which are very similar to Maria spoken in the State. Inside the State, Parjas and Bhatras speak dialects which appear to be akin to Oriya or very much influenced by it. In the south and south-east the language is Telugu while along the western border debased form of Marhatti is spoken by a number of scattered communities. The interior of the State is inhabited by various aboriginal groups who speak their respective dialects all affiliated to the Gondi, more or less influenced by border languages in accordance with their proximity to them or the intensity of their contacts with people speaking those languages. The only representative of the Munda speaking people perhaps are the Gadabas who are a small occupational group, palanquin bearers

by profession, living east of Jagdalpur but who now have lost much of their original culture traits.

Measurements were taken on 463 individuals belonging to 9 cultural groups in Bastar, viz., Dhakars, Halbas, Bhatras, Parjas, Gadabas, Murias of Kondagaon, Murias of Narayanpur, Dandami Marias and Hill Marias. We could get measurements of 51 Muria females from Kondagaon and Narayanpur and for purposes of comparison we measured 50 Nawagharia Gonds living in Akaltara, C.P. Sixteen characters were chosen for treatment and all measurements were taken with Herman and Rickenboch's anthropometric instruments. The following measurements were recorded:—

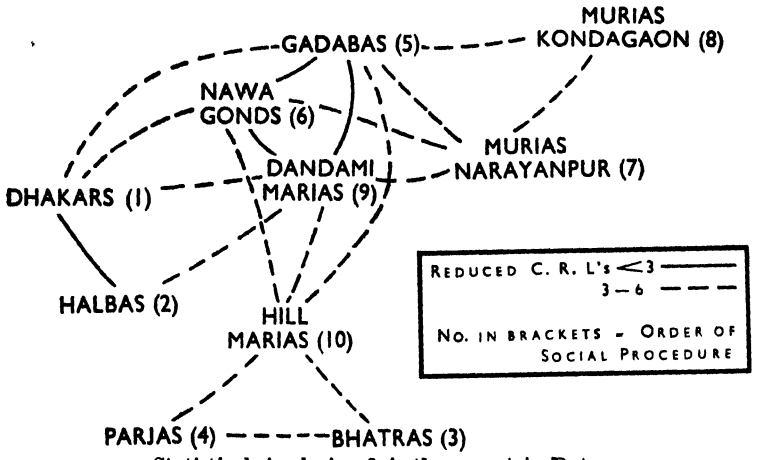
(1) Stature, (2) Span, (3) Auricular Height, (4) Maximum Head Length, (5) Maximum Head Breadth, (6) Maximum Bizygomatic Breadth, (7) Bigonial Breadth, (8) Nasal Length, (9) Nasal Width, (10) Nasal Height, (11) Orbitonasal Breadth, (12) Orbitonasal Arc, (13) Upper Facial Length, (14) Total Facial Length, (15) Nasion to Crinion, (16) Crinion to Menton.

In the case of females, span was left out for obvious reasons. Definitions of important measurements are given below. The head length was taken from the glabella to the most distant part of the occiput. Head breadth was first taken over the hair, then by parting the hair at points which gave the maximum diameter, the difference was however negligible. The facial height was taken as the distance between the nasion and the mid-point on the anterior surface of the lower jaw. The most depressed part at the root of the nose was taken as the 'nasion' for obvious difficulties in locating it. The bizygomatic breadth was measured by running the callipers backwards along the zygomatic arches until maximum reading was obtained. Nasal length was taken from the nasion to the subnasal point, i.e. at the angle formed by the septum of the nose and the upper lip. Nasal breadth was taken across the lateral surfaces of the alae 'with the nostrils deflated and the tip of the nose unwrinkled'. From the definitions above it will appear that most of the measurements are comparable to existing series. I have used nasal height for depth or elevation of the nose.

The crude data were sent to the Indian Statistical Laboratory, Calcutta, where they were calculated under Prof. P. C. Mahalanobis's supervision. My grateful thanks are due to Prof. Mahalanobis on this account. The coefficient of racial likeness crude as well as corrected were worked up at Lucknow by me with the assistance of Mr. S. P. Agarwalla, a student of mine also trained in Prof. Mahalanobis's laboratory. I am also much indebted to Dr. G. M. Morant of the Galton laboratory for the many valuable suggestions and general revision of the paper.

In computing the C.R.L. I have taken 16 characters only. But these characters are all absolute in the sense that they do not include any indical relationship, though they represent linear,

arcal and characters denoting shape and size as well. The means and standard deviations of the characters have been given in Tables 1 to 5.



Statistical Analysis of Anthropometric Data.

If we take 0–3 as intimate association, 3–9 as association and above 9 as divergence (?), we get the relationships as shown in the diagram above. It shows the alignment of the different cultural groups with respect to the Hill Marias who are the most primitive group in Bastar and shows the affiliation of the Dhakars to the other cultural groups. The Nawagharia Gonds as we have already pointed out do not belong to Bastar but they afford a basis of comparison of the data on the cultural groups of Bastar with Gonds of other parts.

The arrangement above indicates the closer affinity of the Hill Marias to the Bhatras, Parjas, Dandami Marias, Nawagharia Gonds, Gadabas and Murias of Narayanpur than to the Murias of Kondagaon, the Halbas and Dhakars. The Dhakars show intimate association with the Halbas, but also show affinity to the Murias of Narayanpur, Gadabas, Dandami Marias and Nawagharia Gonds. The association of the Dhakars with the Hill Marias, Murias of Kondagaon, Parjas and Bhatras is not very close as will appear from the values of the coefficients of racial likeness. These relations indicate a large scale ethnic miscegenation in Bastar and it may be suggested that the groups speaking the same or allied languages are more intimately related than those speaking different dialects. The Murias of Kondagaon, however, presents a difficulty, for it is well nigh certain that they belong to the same stock as the Murias of Narayanpur and cultural differences, that have been brought out between them by Grigson, do not support the theory of separate origin of these two groups.

The mean age in the case of the Murias of Kondagaon is 25·10±0·73, and the standard deviation of age is 5·24±0·51, while the corresponding values for the Murias of Narayanpur are 29·33±1·23 and 8·87±0·87. The standard deviations of the age distribution of the two groups show that the Murias of Kondagaon measured by me were a more homogeneous group than the Murias of Narayanpur and the reason was that the Murias of Kondagaon included the inmates of two dormitories and as such a certain age grade preponderated in the crowd. Otherwise it is not possible to explain such differences between them. We have already described in "Culture Contacts and Acculturation", Presidential Address, Anthropology Section, Indian Science Congress, 1939, the strong dormitory organization among the Murias of Kondagaon and this is incompatible with a large scale or free crossing of the Murias with other groups. Further corroboration of the above will be found in the low values of the standard deviations of the absolute characters.

The close affinity between the Dhakars and the Halbas, both immigrant groups in Bastar is to be expected. Also the arrangement in the diagram shows a closer correspondence with social status than with the geographical distribution of the groups. The Parjas and Bhatras though they speak Oriya or some patois with preponderating Oriya influence do not differ much from the Hill Marias, so that the racial affiliation with the latter is established. The Nawagharia Gonds are not a closed group and so also the Dandami Marias and the association of the latter with the Dhakars and Halbas may mean an intermixture which is popularly admitted in Bastar. This intermixture therefore explains the absence of an intimate association of the Dandami Marias with the Hill Marias. Gadabas do not represent a pure ethnic stock and though their dialect may be traced to Munda origin their physical features do not warrant such affiliation.

A discussion of the significance ratios provides further evidence of the inter-relation of the cultural groups as suggested by the C.R.L. method. The significance ratio is the difference of the means expressed in terms of the square root of the sum of the squares of the probable error of the means and is calculated from the formula:

$$\frac{\Delta\, m - m'}{\sqrt{(\text{P.E.}m)^2 + (\text{P.E.}m')^2}}$$

The significance ratio is taken to determine how far on the basis of the laws of chance sample m and sample m' might have been drawn at random from a single population. Although this ratio should not be interpreted as a measure of the degree of racial difference, it may indicate how far the two samples are entitled to 'separate consideration and mutual comparison'.

The means and standard deviations of 16 physical characters for the entire series are to be found in Tables 1–7. In comparing the constants a difference greater than *three* is taken as significant, and a difference between 2 and 3 as *doubtful* and below 2 as insignificant. In Table 5 (pp. 54–56) the significance ratios are given, only values above 2 are recorded.

The Parjas appear to be the tallest group with a mean stature of 162·32±0·88, next come the Hill Marias with 162·06± 0·69. The Dandami Marias are the next tall group. The Halbas and Dhakars occupy the 7th and 8th places in stature with 158·17±0·83 and 158·09±0·72. The significance ratios for stature affiliate the Hill Marias with the Parjas, Bhatras, Narayanpur Murias while they are entitled to separate consideration from the Dhakars Halbas, Gadabas, Nawagharia Gonds and Kondagaon Murias while their relations with Dandami Marias are doubtful. Unlike many areas, the mountain group is found to possess the tallest stature and better general health than the settled groups. The Dandami Marias are certainly an offshoot of the Hill Marias but they possess to-day a smaller stature than their wild brethren. The higher groups which are known to have freely mixed with the tribal people possess smaller stature compared with the latter, so that the invading groups in Bastar did not probably belong to any tall stock.

The span measurements do not tell a different tale. There is a correlation between stature and span so that the group with the highest mean stature possesses the highest span measurement. The significance ratios between the Dandami Marias and Dhakars, Gadabas and Kondagaon Murias and Halbas are doubtful. The Hill Marias differ significantly from the Dhakars, Gadabas and Kondagaon Murias but the significance ratio between them and Halbas is (2·24) indicating doubtful relationship. The Bhatras differ significantly from the Dhakars (3·90), Gadabas (3·22) and Kondagaon Murias (3·85).

From the head measurements it appears that there is a progressive lengthening of the head towards the mountain regions as is illustrated by the fact that the Hill Marias possess the longest head (184·57), next to them come the Bhatras with (184·43) and then the Kondagaon Murias (183·58). The Bhatras are immigrants while the Kondagaon Murias inhabit hilly tracts. The mean headlength for the Gadabas and Dhakars are (182·77) and (182·26) respectively. The Halbas possess the lowest mean headlength (179·82) which compares favourably with that of the Dandami Marias (180·50). There is no doubt that the Halbas are more mixed than the Dhakars and their admixture with the Dandami Marias is perhaps responsible for the lowering of the mean head length for the latter as well. The mean head breadth for the mountain groups, viz. the Hill Marias and Kondagaon Murias are less than those of the Halbas, Dhakars and Nawagharia Gonds who are plains people. The Parjas have the

highest mean head breadth (140·48), then come the Halbas with (139·82) and Bhatras (138·94). The cephalic indices (calculated from the mean head length and head breadth of the groups) confirm the suggestions already made above, for the Hill Marias (74·20), Kondagaon Murias (73·04) and Gadabas (74·27) possess an index below 75, the Bhatras (75·33), Dandami Marias (75·96), Dhakars (75·17), Nawagharia Gonds (75·31) possess an index between 75 and 76, while the Parjas (77·79) and Halbas (77·75) show a tendency to brachycephaly. The Gadabas have mixed with the Murias, for to-day, the Gadabas do not consider themselves different from the Murias though linguistically they may be affiliated to the Munda speaking groups of Chota-Nagpur in Bihar. The cephalic index of the Munda tribes is not higher than 75 and even if the Gadabas have mixed with the Murias there has not been any change in the value of the index. The Dhakars and Halbas as well as Parjas and Bhatras appear to have been originally mesocephalous or brachycephalous and their mixture with the indigenous groups who are dolichocephals may have contributed to a pronounced mesocephaly in their head form. The Muria females possess a mean cephalic index of 74·48 indicating a close approximation to the Muria males.

In the Bizygomatic measurement, significant ratios are found between Kondagaon Murias and Bhatras (4·10), Kondagaon Murias and Hill Marias (3·88) and Kondagaon Murias and Nawagharia Gonds (3·08). There is little difference between other groups and if there is, it is at best doubtful. The Bhatras have the highest mean Bigonial breadth (100·59) and the Murias of Kondagaon the lowest (94·46). The significance ratio between them is 6·88. There is no significant difference between other groups.

The nasal length cannot be explained in terms of geographical environment, for although the Dhakars (46·00) and Halbas (46·53) possess longer nose, the mean nasal length of the Hill Marias is 46·16. The Kondagaon Murias have the lowest mean nasal length (43·19) and as such there is significant difference between them and the Dhakars (5·62) and Gadabas (3·88), the Halbas (7·06), the Bhatras (5·44) and the Dandami Marias (4·22). If we exclude the Kondagaon Murias, there is not much difference between other groups with regard to this character. In nasal breadth, the highest mean value is given by the Bhatras (39·09), and the Hill Marias, Gadabas and Parjas have a mean nasal breadth between 38 and 39. The nasal index is usually a measure of social status in India and this is corroborated by the values of nasal indices obtained in Bastar. The Dhakars have the lowest mean nasal index (77·91) and the Halbas follow the Dhakars closely with (79·28). The Kondagaon Murias have the highest nasal index (85·52), the Gadabas (84·37), the Dandami Marias (83·62) and the Hill Marias (83·03). The Bhatras and Parjas possess a high mean nasal index, the former 85·14, the

latter 83·79 which are higher than that of the Hill Marias. Thus except the Kondagaon Murias, there appear to be two strains one represented by the Dhakars and Halbas and the other by the Bhatras and Parjas and the rest of the groups are intermediate in type between these two extremes. It must be noted here that the difference between the various cultural groups is not such as to warrant the suggestion that they belong to different ethnic stocks, particularly this is true of tribal groups, but it shows that although the Dhakars and Halbas have ratained their social status they have considerably mixed with other groups which fact has certainly influenced the nasal indices of other groups.

The auricular height and nasal height do not give any new information as there is no striking significance ratios between the groups. In orbito-nasal breadth, the Hill Marias differ significantly from the Murias and Dandami Marias, the Bhatras from Kondagaon Murias, the Parjas from the Kondagaon Murias. The Dhakars do not differ from any of the other groups in this character except from the Bhatras (3·22). In orbito-nasal arc the Bhatras have significant ratio with Kondagaon Murias (5·53) and Narayanpur Murias (5·04) while the ratio between Kondagaon Murias and Parjas, Nawagharia Gonds, Hill Marias is also significant.

In total facial length, there is no striking difference between the groups and the only significant difference exists between the Hill Marias and Kondagaon Murias (3·19) also between Hill Marias and Nawagharia Gonds (3·93). The Bhatras have a significant ratio of (3·29) with Nawagharia Gonds. In upper facial length significant difference is found between Dandami Marias and Dhakars (3·47), Dandami Marias and Kondagaon Murias (3·11), between Dhakars and Bhatras (3·19). The other ratios are insignificant or doubtful.

We have already interpreted the significant differences found to exist between the various groups of Bastar on the basis of the study of the dispersal values of the significant ratios. It appears that the various groups measured do not differ much from one another. Except between the Kondagaon Murias and Bhatras (mean significant ratio 3·88), between the former and the Parjas (Mean S.R. 3·23) and also the Hill Marias (M.S.R. 3·02) there is no striking significant ratios between other groups as will appear from the calculated mean significant ratios in the Tables. Most of the mean significant ratios fall below unity as for example between Halbas and Nawagharia Gonds (0·69), Halbas and Parjas (0·72), Parjas and Hill Marias (0·67), Narayanpur Murias and Kondagaon Murias (0·77), Narayanpur Murias and Nawagharia Gonds (0·94), Parjas and Dandami Marias (0·91), Gadabas and Dhakars (0·88), Halbas and Dhakars (0·54), Gadabas and Narayanpur Murias (0·71) and Gadabas and Nawagharia Gonds (0·14), Gadabas and Parjas (0·77). About 13 of the

relations show mean significant ratios between 1 and 2 and only 4 show mean significant ratios between 2 and 3.

The Table below will give an idea about the respective distance of the cultural groups with respect to the indical characters (cephalic and nasal).

Name of the group.	Cephalic index.	Name of the group.	Nasal index.	Order of social precedence in the state.
Kondagaon Murias	73·04	Kondagaon Murias	85·52	(1) Hill Marias.
Hill Marias	74·20	Bhatras ..	85·14	(2) Dandami Marias.
Gadabas ..	74·27	Gadabas ..	84·37	(3) Gadabas.
Narayanpur Murias	74·42	Parjas ..	83·79	(4) Murias Kondagaon.
Muria (Fem.)	74·88			
Dhakars ..	75·17			
		Dandami Marias	83·62	(5) Murias Narayanpur.
Nawa. Gonds	75·31	Hill Marias ..	83·03	(6) Parjas.
Bhatras ..	75·33	Nawagharia Gonds	81·49	(7) Bhatras.
Dandami Marias	75·96	Narayanpur Murias	81·12	
		Muria Females	80·96	
Halbas ..	77·75	Halbas ..	79·28	(8) Halbas.
Parjas ..	77·79	Dhakars ..	77·91	(9) Dhakars.

The Nawagharia Gonds of C.P. should be placed between Bhatras and Halbas in the Table above. The Hill Marias, Murias both of Kondagaon and Narayanpur and Gadabas, all are dolichocephals, the Bhatras, Parjas, Halbas, Dhakars, Nawagharia Gonds and Dandami Marias are mesocephalous. The Halbas and Dhakars have nasal indices of 79·28 and 77·91 respectively, all the rest have their nasal indices between 80 and 86. It appears that although the tribal groups are not found to follow the order of social precedence with respect to the indical characters it is interesting that the Halbas and Dhakars, the two high castes in Bastar have maintained their social distance from the tribal groups. The intra-tribal social distance is more or less artificial as it depends on the proximity of the tribal groups to the castes. The economic interdependence of the tribal groups and higher castes have brought some of these tribes into close association with the castes which have provided them social status and a place in the social hierarchy of the state. Though the higher castes have maintained their social precedence, their physical type has undergone considerable change and to-day thin partition divides them from the tribal stock.

So far as the indefinite characters are concerned, the differences between the various groups in Bastar are not easily discernible. The Parjas are the tallest among these, their complexion varies from brown to dark, the face is slightly prognathous and the chin receding but no traces of epicanthric fold were found in any individual. Compared to other cultural groups, the Parjas appear to have some distinct ethnic traits, with the Bhatras as the closest of their kins. The Bhatras however do not show much of prognathism or receding chin and on the whole they conform to the general type in Bastar, though individuals among the Bhatras bear more close similarity to the Parjas than to Dhakars or Marias. The Bhatras do not recognize the Parjas as their kith and kin though the latter would unhesitatingly affirm their close relationship with the former. The Hill Marias are tall, handsome and graceful. Some possess a light brown complexion and few of them would answer to the aboriginal description. The hair is plentiful on the face and scalp, the limbs are well proportioned and give the idea of great power. The Dandami Marias have a variety of features in them and often it is difficult to tell a Dandami Maria from a Halba or even a Dhakar but they certainly differ from the Parjas, the chin is well developed, the nose prominent and forehead vertical. The Maria women, Hill as well as Dandami, have finer features than those possessed by the women among the Parjas. The Murias of Kondagaon as well as of Narayanpur resemble the Marias but the latter are more akin to the Hill Marias than the Murias of Kondagaon. There is hardly much to choose between the women of the two sections of the Murias and it is possible that settled life among the Murias of Narayanpur has something to do with their general appearance.

The Gadabas are a problem. In appearance they do not differ from the Murias. They have a dark complexion but brown skins are pretty frequently found among them. The eyes are large and expressive, the nose thin and well developed but the hair is less plentiful than among the Marias or Dandamis, the cheek bones are a little more prominent among them than among the Murias or Marias. Whatever be their origin, to-day they have lost their ethnic identity and are not different from the Murias from whom they would freely take food and water.

The Halbas and Dhakars are closely related, though the Dhakars as a caste possess better features. The complexion varies from tawny brown to pale brown and persons with fair complexion are not rare among them. The forehead is high and vertical, the nose prominent though not very high, the eyes are dark brown and black. On the whole their features are more regular than those of any other group and compare favourably with those of the Kshattriyas in other parts of Chattisgarh. But frequently one meets with Dhakars whose features do not

affiliate them with the description given above and it is perhaps true that nowhere the effects of intermixture are more evident than in Bastar which may be called the melting pot of races.

The results of 16 measurements on 564 persons indicate that there is a correspondence between social types and ethnic types. On the whole the lower the cultural stage, the longer the head and flatter the nose. The Dhakars and Halbas represent the higher castes in Bastar and they possess lower nasal indices than other groups. The difference between the groups are not very wide and that is why the mean significance ratios between them are not at all striking. They may all be taken to represent one ethnic type and with the exception of Dhakars all the other groups answer to a common racial type. This may be called the Gond type as comparison of the racial traits of Bastar Gonds with those of the Nawagharia Gonds does not indicate any great divergence of types. Whether we call this type Gondide or Proto-Mediterranean or Mediterranean the historic Gonds did not belong to the Australoid type we find in the aboriginal population of India, in Chota-Nagpur and elsewhere. The suggestion that the Maria Gonds may belong to the Naga stock which is inferred on the basis of alleged similarity of culture between them and the possession of Mongoloid features by individual Marias is interesting no doubt but extremely hypothetical.

Two alternative explanations suggest themselves. Either the ethnic types that have contributed to racial miscegenation in Bastar are not widely divergent, so that the Bastar type though a mixed one answers to the descriptions both of the Dhakars and Gonds, or the Dhakars and Halbas who represent the higher castes in the State have mixed to produce an intermediate type characterized by mesorhine noses and mesocephalic heads, though originally they were brachycephals and mesorrhine. This latter explanation is plausible in view of recent knowledge about the social and biological effects of race crossing. 'As far as can be ascertained', writes J. C. Trevor, 'from the best evidence available, the cross results in a nearly perfect blending of average values, determined by the proportions in which the parent populations have mixed.' These results are not perhaps genetically surprising if the parent populations are themselves highly heterozygous and variable. The variabilities of the crossed series therefore are not necessarily greater than those of the parent populations and if we pin our faith on the variability alone, to determine the purity and homogeneity of the samples, it will give us results which cannot very well be substantiated. On the basis of the arguments given above it is no wonder that the Dhakars and Halbas represent an intermediate type between the tribal type in Bastar and a type which may be ancestors to the Dhakar and Halba type characterized by brachycephaly, medium stature with flattened occiput but having also high

head, short orthognathous face, long and often pitched nose, light brown complexion, dark straight hair and dark brown eye colour, a type corresponding to Dr. Guha's B element in the Indian population (Census of India, Vol. I, Pt. III, page lxii).

An interesting example of the formation of cultural groups, the process by which tribes transform themselves into castes is found in Bastar. Grigson in his book on the Maria Gonds of Bastar has referred to this cultural transition. He writes that a large number of persons returned as members of the Hindu functional castes, the graziers, potters, fishermen, weavers, blacksmiths and others, are in reality members of the primitive tribes speaking their language and only differentiated from them by their occupation. There is nothing in their appearance to distinguish these persons from other aborigines of the area, they follow their tribal religions whether enumerated as such or as Hindus.

I measured a group of 35 Kurukhs of Chitrakot who are fishermen and live mostly by fishing in the Indravati river. A comparison of differences of means and standard deviations in terms of their standard errors of two series of measurements on the Kurukhs and Hill Marias indicate very little divergence between the two samples. The constants for the means of 16 absolute characters when compared give all values less than 2 except in the case of one nasal measurement, viz. nasal height which is 2·03. The nasal height is a delicate measurement and such small difference in value may be ignored. In standard deviations also except for the nasal breadth (2·26) and nasal height (2·90) all the other characters do not show any significant difference. Considering all these characters it appears that for all practical purposes the two samples (Kurukhs and Hill Marias) may be taken to represent the same population. The cephalic index of the Hill Marias is 74·20, nasal index 85·52 and stature 162·06 while corresponding figures for the Kurukhs are 74·50, 84·20 and 161·54. The result, however, should be regarded as extremely significant as such comparisons may lead to the identity of tribal groups with castes thereby explaining the transition of tribes into castes.

TABLE 1.

Comparative Indices for series of Bastar State, Males and Females.

	Cephalic Index.	Nasal Index.	Orbito-Nasal Index.	Total Facial Index.
Murias of Kondagaon ..	73·04	85·52	110·19	89 98
Murias of Narayanpur	74·42	81·12	109·70	90·21
Gadabas	74·27	84·37	110·20	89·09
Hill Marias ..	74·20	83·03	109·60	90·09
Dhakars	75·17	77·91	109·91	89·83
Halbas	77·75	79·28	110·38	90·58
Parjas	77·77	83·79	110·00	90·04
Bhatras	75·33	85·14	111·55	89·61
Nawagharia Gonds ..	75·31	81·49	111·89	87·83
Dandami Marias ..	75·96	83·62	110·30	89·95
Muria Females ..	74·88	80·96	108·32	88·59

TABLE 2.

*Mean Age and Standard Deviation (with Standard Errors) for groups of Bastar Males, one group of females and one of C.P. Gonds.**

	(54) Bhatras.	(50) Dandami Marias.	(50) Dhakars.	(51) Halba.	(51) Hill Maria.	(51) Muria Narayanpur.	(52) Muria Kondagaon.	(50) Nawagharia Gonds.	(50) Parjas.	(52) Muria Females.	(52) Gadaba.
Mean Age	36·70 ±1·13	29·46 ±1·24	35·66 ±1·28	37·92 ±1·19	31·33 ±1·12	29·33 ±1·23	25·10 ±0·73	33·20 ±1·61	30·38 ±1·25	33·69 ±1·30	35·42 ±1·04
Standard Deviation ..	8·34 ±0·80	8·77 ±0·88	9·06 ±0·91	8·49 ±0·84	7·98 ±0·79	8·87 ±0·87	5·24 ±0·51	11·40 ±1·14	8·85 ±0·88	9·34 ±0·92	7·49 ±0·73

* In all cases the ages were estimated by the observer with the assistance of a few elders of the villages concerned.

Comparative Means for series of Bastar State Males (with Standard Errors), one group of C.P. Gonds and one female group (from Bastar).

	Dandami Marias (50) ♂	Bhatras (54) ♂	Dhakars (50) ♂	Gadaba (52) ♂	Halba (51) ♂	Hill Maria (51) ♂	Muria Narayanpur (52) ♂	Muria Kondagaon (52) ♂	Gonds Nawagharia (50) ♂	Parjas (50) ♂	Muria Females (52) ♀
Stature	159·48	160·91	158·17	158·04	158·09	162·06	160·61	157·79	158·74	162·32	147·93
	±0·86	±0·79	±0·83	±0·81	±0·72	±0·69	±0·74	±0·68	±0·74	±0·88	±0·58
Span	172·70	173·63	168·28	169·44	170·84	173·76	171·54	169·08	171·76	174·22	..
	±1·09	±0·84	±1·09	±0·79	±0·93	±0·91	±1·03	±0·83	±0·94	±1·20	..
Head Length ..	180·50	184·43	182·26	182·77	179·82	184·57	182·37	183·58	182·42	180·58	176·46
	±1·00	±0·75	±0·83	±0·80	±1·04	±0·73	±0·72	±0·85	±0·74	±0·95	±0·82
Head Breadth ..	137·12	138·94	137·02	135·75	139·82	136·96	135·73	134·10	137·38	140·48	131·44
	±0·73	±0·65	±0·64	±0·76	±0·76	±0·56	±0·52	±0·30	±0·61	±0·71	±0·57
Auricular Height ..	12·80	13·0	12·67	12·89	12·93	13·02	13·03	12·79	12·81	13·09	12·67
	±0·08	±0·07	±0·08	±0·08	±0·10	±0·09	±0·07	±0·10	±0·08	±0·07	±0·09
Nasal Length ..	45·30	45·91	46·00	45·13	46·53	46·16	45·46	43·19	45·72	45·54	42·98
	±0·42	±0·40	±0·44	±0·36	±0·55	±0·34	±0·42	±0·40	±0·41	±0·53	±0·45
Nasal Breadth ..	37·88	39·09	35·84	38·08	36·88	38·33	36·98	36·94	37·26	38·16	34·80
	±0·34	±0·34	±0·34	±0·34	±0·46	±0·35	±0·32	±0·28	±0·34	±0·39	±0·32
Nasal Height ..	20·56	21·96	19·84	20·46	21·12	20·24	18·81	18·96	20·04	20·80	17·77
	±0·28	±0·26	±0·22	±0·16	±0·28	±0·29	±0·22	±0·22	±0·24	±0·22	±0·21
Bizygomatic Breadth ..	128·82	130·41	128·48	128·96	128·61	130·63	128·08	127·13	129·72	129·54	121·13
	±0·67	±0·59	±0·60	±0·74	±0·66	±0·71	±0·58	±0·57	±0·61	±0·70	±0·59
Bigonial ..	96·00	100·59	96·34	95·64	96·75	96·67	94·63	94·46	94·54	96·82	87·69
	±0·83	±0·66	±0·67	±0·72	±0·85	±0·79	±0·80	±0·61	±0·75	±0·66	±0·50
Nasion to Crinion ..	55·86	58·19	54·12	59·19	52·78	56·43	56·52	57·19	59·22	61·32	52·90
	±0·77	±0·73	±0·78	±0·74	±0·94	±0·82	±0·86	±0·73	±0·67	±1·13	±0·66
Crinion to Menton ..	166·64	169·80	163·86	167·58	164·02	169·47	168·00	166·35	166·04	170·58	157·44
	±1·05	±0·85	±1·10	±0·93	±1·09	±0·97	±0·95	±1·00	±0·99	±1·55	±1·16
Total Facial Length ..	115·88	116·87	115·42	114·79	116·49	117·69	115·65	114·40	113·94	116·64	107·31
	±0·59	±0·73	±0·77	±0·68	±0·98	±0·80	±0·69	±0·65	±0·52	±0·97	±0·83
Upper Facial Length ..	65·08	64·63	62·30	63·12	63·31	63·96	64·08	62·12	63·70	64·30	59·67
	±0·63	±0·54	±0·49	±0·50	±0·64	±0·56	±0·46	±0·71	±0·47	±0·56	±0·55
Orbito-Nasal Breadth ..	97·46	98·72	97·88	97·75	97·65	99·63	96·92	95·88	97·80	98·72	94·15
	±0·40	±0·44	±0·38	±0·53	±0·54	±0·49	±0·44	±0·48	±0·36	±0·64	±0·31
Orbito-Nasal Arc ..	107·50	110·13	107·58	107·73	107·80	109·20	106·33	105·65	109·48	108·60	101·98
	±0·56	±0·49	±0·62	±0·64	±0·64	±0·67	±0·57	±0·64	±0·43	±0·75	±0·48

TABLE 4.

Comparative Standard Deviations for series of Bastar Males (with Standard Errors), one group of Muria Females of Bastar and one group of Nawagharia Gonds of C.P.

	(54) ♂ Bhatras	(50) ♂ D. Marias	(50) ♂ Dhakars	(52) ♂ Gadba	(51) ♂ Halba	(51) ♂ Hill Maria	(52) ♂ Muria	(52) ♂ Murias	(50) ♂ Nawa-gharia Gonds	(50) ♂ Parjas	(52) ♀ Muria Females
Stature ..	5·83±0·56	6·09±0·61	5·86±0·59	5·87±0·57	5·15±0·57	4·94±0·49	5·31±0·52	4·88±0·48	5·25±0·52	6·20±0·62	4·19±0·41
Span ..	6·15±0·59	7·70±0·77	7·74±0·77	7·12±0·70	6·62±0·66	6·53±0·65	7·46±0·73	5·95±0·58	6·62±0·66	8·50±0·85	
Head Length	5·54±0·53	7·05±0·71	5·86±0·59	5·80±0·57	7·43±0·74	5·18±0·51	5·16±0·51	6·13±0·60	5·22±0·52	6·74±0·67	5·94±0·58
Head Breadth	4·79±0·46	5·16±0·52	4·54±0·45	5·51±0·54	5·43±0·54	3·59±0·36	3·72±0·37	2·16±0·21	4·33±0·43	4·99±0·50	4·11±0·40
Auricular Height	0·55±0·05	0·54±0·06	0·53±0·06	0·58±0·06	0·71±0·07	0·68±0·07	0·50±0·05	0·73±0·07	0·54±0·06	0·53±0·05	0·62±0·06
Nasal Length	2·95±0·28	2·96±0·30	3·13±0·31	2·58±0·25	3·96±0·39	2·46±0·24	3·01±0·30	2·91±0·29	2·93±0·29	3·76±0·37	3·26±0·32
Nasal Breadth	2·50±0·24	2·42±0·24	2·37±0·24	2·47±0·24	3·28±0·33	2·50±0·25	2·34±0·23	2·05±0·20	2·39±0·24	2·75±0·28	2·29±0·23
Nasal Height	1·91±0·18	1·96±0·20	1·58±0·16	1·15±0·11	2·02±0·20	2·06±0·20	1·58±0·16	1·62±0·16	1·71±0·17	1·54±0·16	1·53±0·15
Bizygo. Breadth	4·32±0·42	4·73±0·47	4·26±0·42	5·37±0·52	4·70±0·47	5·07±0·50	4·15±0·41	4·08±0·40	4·31±0·43	4·94±0·49	4·29±0·42
Bigonial Breadth	4·88±0·47	5·90±0·59	4·74±0·47	5·20±0·51	6·09±0·60	5·66±0·56	5·80±0·57	4·41±0·43	5·34±0·53	4·65±0·47	3·58±0·35
Nasion to Crinion	5·40±0·52	5·41±0·54	5·43±0·55	5·36±0·52	6·73±0·66	5·84±0·58	6·22±0·61	5·30±0·52	4·76±0·47	7·98±0·80	4·75±0·47
Crinion to Menton	6·26±0·60	7·39±0·74	7·81±0·78	6·71±0·66	7·81±0·77	6·95±0·69	6·84±0·67	7·20±0·71	7·00±0·70	10·93±1·10	8·39±0·82
Total F. Length	5·33±0·52	4·15±0·42	5·46±0·54	4·92±0·48	6·97±0·69	5·73±0·57	4·94±0·49	4·68±0·46	3·66±0·37	6·84±0·69	6·01±0·59
Upper F. Length	3·98±0·38	4·48±0·45	3·44±0·35	3·46±0·35	4·58±0·45	3·98±0·39	3·33±0·33	5·10±0·50	3·31±0·33	3·99±0·40	3·97±0·39
Orbito-N. Breadth	3·26±0·31	2·81±0·28	2·67±0·27	3·85±0·37	3·88±0·38	3·48±0·34	3·20±0·31	3·43±0·34	2·58±0·25	4·56±0·45	2·23±0·22
Orbito-N. Arc ..	3·61±0·35	3·96±0·40	4·38±0·44	4·59±0·45	4·59±0·45	4·79±0·47	4·13±0·40	4·64±0·45	3·07±0·30	5·27±0·53	3·48±0·34

Bizygo. = Bizygomatic; F. = Facial; N. = Nasal.

TABLE 5.

Significance Ratios for the Bastar Series and one group of N.G. Gonds. (Comparison of Means and Standard Errors.) (Values above two are given.)

	Bhatras and D. Marias.	Bhatras and Dhakars.	Bhatras and Gadabas.	Bhatras and Halbas.	Bhatras and Hill Marias.	Bhatras and Murias.	Bhatras and K. Murias.	Bhatras and N.G. Gonds.
Stature ..	..	2·40	2·54	2·63	..	..	3·00	2·00
Span ..	..	3·90	3·22	2·23	..	..	3·85	..
A.H. ..	1·88	3·30	..	..	..	..	..	..
H. Length ..	3·14	..	..	3·60	..	..	..	..
H. Breadth ..	..	2·10	3·15	..	2·41	4·00	6·76	..
N. Length ..	..	..	..	..	..	..	5·44	..
N. Breadth ..	2·52	6·77	2·10	4·01	..	4·58	5·37	3·81
N. Height ..	3·69	6·23	5·00	2·21	4·52	9·21	8·90	6·40
Bizygomatic	..	2·32	..	2·25	..	2·91	4·10	..
Bg. ..	4·33	4·61	5·54	3·59	3·84	5·79	6·88	6·61
N.C. ..	2·19	3·84	..	4·54	..	..	..	..
C.M. ..	2·34	4·27	..	4·18	..	..	2·64	2·89
ONB ..	2·13	..	..	..	..	2·90	4·36	..
ONA ..	3·55	3·22	2·96	2·87	..	5·04	5·53	..
TFL ..	..	..	2·10	..	..	..	2·54	3·29
UFL ..	..	3·19	2·06	..	..	..	2·82	..
Mean Sig. Ratio ..	1·61	2·88	1·79	1·88	0·67	2·15	3·88	1·56

	Bhatras and Parjas.	Dandarin Marias and Dhakars.	D. Marias and Gadabas.	D. Marias and Halbas.	D. Marias and Hill Marias.	D. Marias and N. Murias.	D. Marias and K. Murias.	D. Marias and N.G. Gonds.
Stature ..	..	..	..	..	2·34	..	..	..
Span ..	..	2·27	2·27	..	..	..	2·70	..
A.H. ..	..	..	..	..	..	2·30	..	..
H. Length ..	3·18	..	..	..	3·30	..	2·37	..
H. Breadth ..	..	..	..	2·45	..	..	4·31	..
N. Length ..	..	..	..	..	..	..	4·22	..
N. Breadth ..	..	4·25	..	..	..	..	2·13	..
N. Height ..	3·41	2·05	..	..	..	5·00	4·85	..
Bizygomatic	..	..	..	..	..	..	2·01	..
Bg. ..	3·85	..	..	..	..	..	..	..
N.C. ..	4·47	..	3·11	2·52	..	..	..	3·29
C.M. ..	..	..	..	..	..	..	..	..
ONB ..	..	..	..	..	3·44	..	2·54	..
ONA ..	..	..	..	..	..	2·17	2·78	..
TFL ..	..	..	..	..	..	..	..	2·45
UFL ..	..	3·47	2·42	..	..	..	3·11	..
Mean Sig. Ratio ..	0·93	0·75	0·48	0·31	0·56	0·59	1·93	0·35

Significance Ratios for the Bastar Series and one group of N.G. Gonds. (Comparison of Means and Standard Errors.) (*Values above two are given.*)

Continued from the previous Table.

	D. Marias and Parjas.	Dhakars and Gadabas.	Dhakars and Halbas.	Dhakars and Hill Marias.	Dhakars and N. Murias.	Dhakars and K. Murias.	Dhakars and N.G. Gonds.	Dhakars and Parjas.
Stature ..	2·30	..	..	3·60	2·19	..	..	3·43
Span .	..	..	..	3·86	2·17	..	2·41	3·73
A.H. ..	2·90	..	2·03	2·91	3·30	..	..	4·20
H. Length .	..	..	..	2·10	..	..	..	..
H. Breadth ..	3·32	..	2·98	..	..	4·31	..	3·64
N. Length ..	..	..	..	..	..	5·62	..	..
N. Breadth ..	..	4·66	..	5·18	2·85	2·50	2·95	4·64
N. Height ..	..	2·29	3·65	..	3·32	2·83	..	3·09
Bizygomatic	..	..	..	2·38	..	..	..	..
Bg. ..	..	..	..	..	..	2·08	..	..
N.C. ..	3·98	4·68	..	2·04	2·06	2·89	5·06	5·38
C.M. ..	2·11	2·58	..	3·81	2·85	..	..	3·53
ONB ..	..	..	..	2·83	..	3·27	..	..
ONA ..	..	..	..	..	..	2·16	2·53	..
TFL ..	..	..	..	2·04	..	..	..	..
UFL ..	..	..	..	2·30	2·65	..	2·05	2·70
Mean Sig. Ratio ..	0·91	0·88	0·54	2·06	1·58	1·60	0·93	2·14

	Gadabas and Halbas.	Gadabas and Hill Marias.	Gadabas and N. Murias.	Gadabas and K. Murias.	Gadabas and N.G. Gonds.	Gadabas and Parjas.	Halbas and Hill Marias.	Halbas and N. Murias.
Stature ..	..	3·79	2·33	..	..	3·56	3·98	2·44
Span ..	..	3·20	..	..	..	3·06	2·24	..
A.H. ..	..	..	..	..	..	..	..	..
H. Length ..	2·25	..	..	..	..	..	3·65	2·06
H. Breadth ..	3·80	..	..	2·03	..	4·54	..	..
N. Length ..	2·15	2·57	..	3·88	..	..	3·17	4·49
N. Breadth ..	2·18	..	2·39	2·58	..	..	2·90	..
N. Height ..	2·06	..	8·25	7·50	..	..	2·20	6·66
Bizygomatic	..	..	..	..	..	..	2·14	..
Bg. .	..	..	..	..	..	..	..	..
N.C. ..	2·50	2·36	..	..	..	2·96	2·94	3·76
C.M. ..	2·49	..	..	..	..	..	3·73	2·79
ONB ..	..	2·66	..	2·63	..	..	2·71	..
ONA ..	..	..	..	2·28	2·27	..	..	..
TFL ..	..	2·76	..	..	..	..	..	..
UFL ..	..	..	..	..	..	..	..	..
Mean Sig. Ratio ..	1·08	1·07	0·71	1·30	0·14	0·77	1·75	1·37

Significance Ratios for the Bastar Series and one group of N.G. Gonds. (Comparison of Means and Standard Errors.) (Values above two are given.)
Continued from the previous Table.

	Halbas and K. Murias.	Halbas and N.G. Gonds.	Halbas and Parjas.	Hill Marias and N. Murias.	Hill Marias and K. Murias.	Hill Marias and N.G. Gonds.	Hill Marias and Parjas.	N. Murias and K. Murias.
Stature ..	..	..	3·71	..	4·41	3·28	..	2·82
Span ..	..	..	2·22	..	3·80	..	..	..
A.H. ..	..	..		..	..	..	..	..
H. Length ..	2·86	2·04	.	2·15	..	2·08	3·35	..
H. Breadth ..	2·12	2·48	..	..	4·93	..	4·04	2·71
N. Length ..	7·06	..	..	..	5·94	..	..	4·54
N. Breadth ..	..	..	2·13	2·96	3·15	2·22	..	..
N. Height ..	6·17	3·06	..	4·76	3·35	..	..	..
Bizygomatic	..	..		2·83	3·88	..	..	..
Bg. ..	2·12	..	..	..	2·23	..	..	..
N.C. ..	5·60	5·80	..	..	..	2·65	3·49	..
C.M. ..	..	..	3·47	..	2·24	2·49	..	..
ONB .	2·45	..		4·10	5·43	3·00	..	..
ONA ..	2·38	2·18		3·26	3·83	..	..	..
TFL ..	..	2·29	..	..	3·19	3·93	..	..
UFL ..	..	..	..	..	2·02	..	..	2·30
Mean Sig. Ratio ..	1·91	0·69	0·72	1·25	3·02	1·22	0·67	0·77

	N. Murias and N.G. Gonds.	N. Murias and Parjas.	K. Murias and N.G. Gonds.	K. Murias and Parjas.	N.G. Gonds and Parjas.
Stature ..	..	..	..	4·08	3·11
Span .	..	..	2·14	3·29	..
A.H. ..	2·07	..	..	2·45	2·64
H. Length ..	..	..	..	2·36	..
H. Breadth ..	2·06	5·39	5·46	8·28	3·33
N. Length ..	..	..	5·06	3·91	..
N. Breadth ..	..	2·36	..	2·54	..
N. Height ..	4·10	..	3·37	5·93	2·39
Bizygomatic	..	..	3·08	2·67	..
Bg. ..	..	2·12	..	2·96	2·30
N.C. ..	2·47	3·38	2·05	3·08	..
C.M. ..	..	..	..	2·29	2·46
ONB ..	..	2·33	3·20	3·55	..
ONA ..	4·43	2·41	4·84	3·00	..
TFL ..	..	..	..	..	2·45
UFL ..	..	..	..	2·42	..
Mean Sig. Ratio ..	0·94	1·12	1·82	3·29	1·16



FIG. 1 Nawagharia Gond.



FIG. 2 Profile of Fig 1

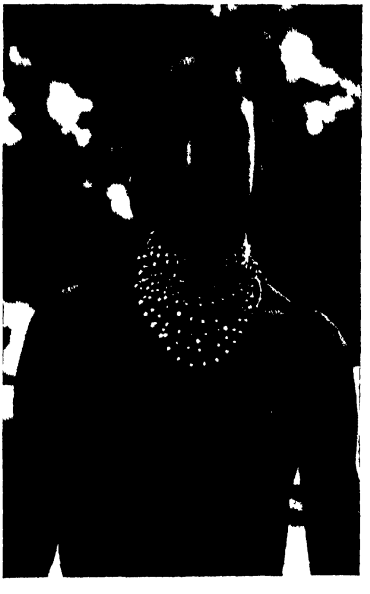


FIG. 3. Muria, Kondagaon, Bastar C P.



FIG. 4. Profile of Fig. 3.



FIG 1 Dandami Maria



FIG 2 Profile of Fig 1.



FIG 3 Hill Maria



FIG 4 Profile of Fig 3



FIG 1 Dhakar



FIG 2 Profile of Fig. 1.



FIG. 3. Gadaba.



FIG. 4. Profile of Fig. 3.



FIG. 1. Muria Youth, Narayanpur.



FIG. 2. Parja, Bastar.



FIG. 3. Profile of Fig. 2.

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ARTICLE No. 6.

Notes on *Cayratia* and *Tetrastigma*.

By FRANKLIN P. METCALF.

(*Communicated by Dr. K. P. Biswas.*)

Recently in connection with the preparation of my 'Flora of Fukien', with notes on South-eastern China, I was unable to settle definitely the status of the two specimens collected in Hainan in 1921 and 1922 by Professor F. A. McClure. These had variously been interpreted as *Columella Wrayi* (King), Merrill, or as *Cayratia papillata* (Hance), Merrill and Chun, which last was considered by Merrill and Chun as possibly being the same as *Cayratia Wrayi* (King), Gagnepain.

Through the kindness of Dr. K. P. Biswas, Superintendent of the Royal Botanical Gardens, Sibpur, Calcutta, India, I have been fortunate in obtaining two photographs of two different sheets of *Scortechini 426* from Perak, as well as a drawing, and 2 or 3 fruits with seeds, this representing one of the syntypes listed by King when he described *Vitis Wrayi*. At the Arnold Arboretum I have a photograph of the type of Hance's species *Vitis papillata* Hance (= *Cayratia papillata*, Merrill and Chun), namely, *Bullock, herb. Hance 20297* from Hoihau, Hainan, and a specimen collected from Hung Mo Shan, Hainan, collected by *Tsang, Tang* and *Fung, LU 17595*, which agrees very well with the photograph of the type of *Vitis papillata* Hance.

A comparison of the available photographs, drawings, and merotype show that the species of King, originally described as *Vitis Wrayi* and that of Hance, originally described as *Vitis papillata*, are the same and that they both represent a species of *Cayratia* and not *Tetrastigma*.

Gagnepain, Merrill and Chun, and more recently Biswas (in litt.) consider this to be a *Cayratia*, not a *Tetrastigma*, though Craib has placed his Siam material under *Tetrastigma*.

The early material from Hainan collected by McClure is something entirely different; it is a species of *Tetrastigma*, apparently undescribed, and is here proposed as a new species.

1. *Cayratia papillata* (Hance) Merrill and Chun, in *Sunyatsenia*, **5**, 118 (1940).

Vitis papillata Hance, *Journ. Bot.*, **16**, 226 (1878).

Vitis Wrayi King, *Journ. Asiat. Soc. Bengal*, 64(2), **8**, 394 (Mat. Fl. Malay Pen. 680) (1896); Ridley Fl. Malay Pen., 475 (1922).

Cayratia Wrayi Gagnepain, Not. Syst., **1**, 346 (1911), and in Lecomte Fl. Gén. Indo-Chine, **1**, 978 (1912).

Tetrastigma Wrayi Craib, Fl. Siam. Enum., **1**, 314 (1926).

This species as now represented extends from Perak to Siam [*Mrs. Collins 649* and *699, ex* Craib], to Indo-China [*Pierre 4432, ex* Gagnepain], and to Hainan [*Bullock, herb. Hance 20297*, type, and *LU 17595* (*Tsang, Tang* and *Fung*), *ex* Merrill and Chun]. No specimens from Indo-China or Siam are available to the writer, but Gagnepain's treatment of this group is very critical, so his crediting of this species to Indo-China is probably correct. I am not so sure of Craib's record for Siam, as he recognizes both *Cayratia* and *Tetrastigma* and still has made the new combination *Tetrastigma Wrayi* (King), Craib, combining the Perak and Siam (Prachinburi and Nawng Kaw) material. His Flora, however, was done at Kew, where he surely had type material of King's species for comparison.

2. *Tetrastigma Biswasiana* Metcalf spec. nov.

Columella Wrayi (King) Merrill, *Ling. Sci. Journ.*, **5**, 122 (1927), *non Cayratia Wrayi* (King) Gagnepain, *excl. syns. cit. et quoad spec. cit. e* Hainan.

Tetrastigma Henryi Merrill and Chun, *Sunyatsenia*, **2**, 39 (1934), *non* Gagnepain.

Frutex scandens, glaber, ramulis ultimis longitudinaliter sulcatis 1·5 mm. diametro, ramis teretibus, internodis 6 ad 8 cm. longis; foliis trifoliatis, petiolo 3·5–6 cm. rare ad 8 cm. longo; foliolis lateralibus oblique oblongo-lanceolatis, apice abrupte acutis vel acuminatis, ad basim rotundatis, petiolulo circiter 8 mm. longo, foliis terminalibus ellipticis, apice abrupte acutis vel acuminatis, ad basim cuneatis, utrinque glabris, leviter reticulatis, viridibus vel olivaceis, venis primariis 7–12 conspicuis, margine subintegerrimis vel distanter et minute denticulatis, glanduloso-apiculatis; petiolulo circiter 30 mm. longo; inflorescentiis axillaribus, pedunculatis, circiter 4–6 cm. longis et 6 cm. rare 10 cm. latis, cymoso-paniculatis, plurifloris, parce et minute puberulentibus; calycibus minutis lobis 4, late triangularibus; petalis glabris, ovatis, 1·2 mm. longis latisque, apice cucullatis dorso corniculatis, corniculo terete, uncinato, obtuso; staminibus minutis; disco undulato vel crenulato; stigmatibus 4-lobis; fructibus ellipsoideis nigris, 5–10 mm. longis et 3–5 mm. latis, pedicello 5 mm. longo parce et minute pubescente.

Hainan: Hong Ma Ts'un, *CCC. 8308* (*McClure*), type, Dec. 3, 1921, (CCC. and AA.). Additional numbers not available now at the Arnold Arboretum and included on the same printed labels, namely, *CCC. 8276, 9194, 9413, 9544*, and also cited by Merrill (l.c.) in his enumeration of Hainan plants, probably represent the same species, but should be seen and verified, as typical *Cayratia papillata* (Hance), Merrill and Chun, has also been collected from one of the same sublocalities, Hung Mo Shan (Five Finger Mountain) in Hainan. The following numbers from Hainan, all originally distributed as *T. Henryi*, Gagnepain, also belong here, namely: Chang-kiang, *S. K. Lau* 1399, Poting,

F. C. How 71657, type of flower, *71766* and *Ko 52206*, and without detailed local locality, *C. Wang 36226* and *S. P. Liang 55220*. The leaflets in *Ko 52206* and *How 71657* are somewhat undulate.

This species in general appearance suggests *Cayratia papillata* (Hance) Merrill and Chun [*Cayratia Wrayi* (King) Gagnepain] but in addition to the fact that this is a *Tetrastigma* and not a *Cayratia*, it can be separated by the broader, more oblong-elliptic leaves, with abruptly acute to acuminate, not gradually acuminate apices, more numerous veins, less prominently denticulate undulate margins, and elliptical, not subglobose, fruits. In *Tetrastigma* its nearest affinity is *Tetrastigma Henryi* Gagnepain, which has more prominently undulate-serrate margins to the 3-4 foliolate to 5 foliate, pedate leaves, and by its pubescent, not glabrous, petals and puberulent, not subglabrous, pedicels of the fruit.

This species is named in honour of Dr. K. P. Biswas, Superintendent of the Royal Botanical Gardens, Calcutta, whose co-operation and courtesy have made the preparation of this paper possible.

ARNOLD ARBORETUM,
Harvard University,
September 4, 1941.

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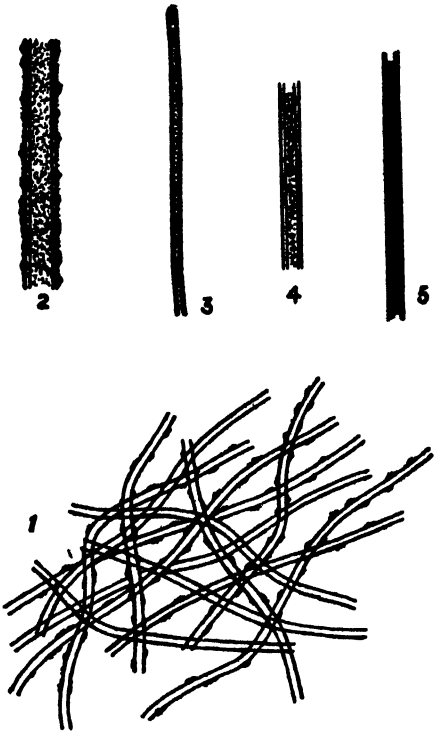
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Journal of the Royal Asiatic Society of Bengal. Science.
Volume VIII, 1942.
ARTICLE No. 1

Notes on the Occurrence of a Cosmopolitan Blue-green Alga in the Hotsprings at Wairaki in the Thermal Region of the North Island of New Zealand.

By K. BISWAS.

The specimen of an alga, which forms the subject of my study, was collected in the middle of April, 1941, by Mrs. Joan Townend while on a visit to the North Island, New Zealand, where her husband Mr. H. P. V. Townend, C.I.E., I.C.S., was then spending his holidays. The alga was received after a period of five months in a dried state as several small patches stuck on to two separate slips of paper. The delay in the receipt of the material was due evidently to the present war condition. One of the specimens is pale yellowish green and the other blue-green. It is noteworthy that the dried specimen of the alga retained much of its original colour of the fresh specimens as found in nature. Mrs. Townend's field observation as noted in her letter to me illustrates clearly the habitat condition of the plant. Her note runs as follows:—'The little specimens of algae I got for you are from the hotsprings at Wairaki in the thermal region of the centre of the North Island of N.Z. The water in which this alga was growing was just cool enough to allow one to put one's hand into it. A little higher up the mountain side, it was boiling. The region is one of many geysers and vent holes with escapes of steam and many different minerals are contained in the various waters. The alga was growing both in pools which are constantly filled by geysers and down the slopes over which they overflow. The spot from which I took this was a series of terraces formed of silicate in the water flowing down from a geyser. A thin film of water constantly passes over the silicate surface which is of yellowish colour and quite hard.' The alga after it was kept in warm water for a quarter of an hour was quite suitable for microscopic examination. After about half an hour some of the portions of the filaments and the hormogones showed even signs of reviving from their desiccated state and exhibited different stages of the growth of the filaments. I am, therefore, able to identify the alga as *Phormidium ambiguum* Gomont, without much difficulty often experienced in tackling such dried, delicate materials of some of the members of the family of *Oscillatoriaceae* to which this alga belongs. When soaked in water the smooth, slimy, coherent blue-green thallus composed of agglutinated filaments indicates undoubtedly its generic characters of *Phormidium.*



EXPLANATION OF FIGURE.

Phormidium ambiguum Gomont.

1. Portion of the plant mass showing the tortuous entangled nature of the filament. ×200.
2. Portion of empty filament showing the nature of the sheath impregnated with Silicon particles. ×650.
3. Portion of trichome with the round apex. ×500.
4. Homogone. ×500.
5. Portion of filament with trichome showing the nature of the cells. ×500.

This species of *Phormidium* forms blue-green, dark or pale yellowish green spreading layer on the substrata. In the present case it was also found to form similar expanded layer on the terraces of silicate over which thin film of water from a geyser constantly flowed down. The plant masses, composed of densely entangled filaments covering portions of the pools, slopes and terraces over which the geysers overflow, lend, as Mrs. Townend says, a definite bluish or yellowish green colour to an extensive area wherever they were noticed to grow. Filaments 4–6μ in diameter, elongated, tortuous in various ways forming a network

over the substratum; sheath mucous, well defined, hyaline, firm, adherent, or sometimes diffluent and often coated with particles of silicon dioxide making filaments somewhat fragile; trichome 3–5μ broad, long, pale yellowish green or blue-green, more or less constricted, apex rounded, without calyptra; crosswalls, which are not so distinct in the dried specimens, appeared sparsely granular; cells shorter than broad or as long as broad, 2μ long, hormogones abundant, cell-contents granular, blue-green. The plant-mass, when kept in water for a week, did not renew its growth in the artificial condition. Treated with dilute HCl (5% aqueous solution) the silica particles become more refractive and the filaments, the trichomes and the cells lose their blue-green colour due to the destruction of the phycocyonin pigments in them; otherwise, they do not seem to be much affected. Gas vacuole (Pseudovacuole) was observed by Lammarman in 1910, but no such vacuole is distinctly present in this form of the alga. Habitat—on stones in hotsprings or in the warm water of the pools and slopes and on rocky terraces over which the water of the geysers flows down.

This is a cosmopolitan species which has been found to grow in hot and cold water, or fresh and brackish water of stagnant pools, running streams, or on wet soil, rocks or wood and other substrata. It is thus adapted to varying ecological conditions and it frequently forms, as in the region of hotsprings of the North Island, New Zealand, more or less a pure association of its own.

This species has been reported from nearly all over the Central and Southern Europe, North America and Tropical Africa. It has also been noted to occur as far east as Ceylon by Ferguson, Maymyo and Burma by S. L. Ghose, and Thailand (Siam) by Volz. Gomont was the first to discover this alga and described it in his *Monographie Des Oscillariees*, p. 178, Tab. 5, fig. 10, 1892, and subsequently other algologists recorded the species in their works under various names, such as, *Amphithrix amoena* Kuetz : Phyc. gen., p. 220 ; Sp. Alg. p. 274 ; Tab. Phyc. I, p. 45, t. 79, f. I ; *Phormidium lyngbyaceum* Fres. in Rab. exs. n. 75; Rab. Fl. Eur. Alg. II, p. 124 ; non Kuetz.; *Phormidium papyrinum* de Bary in Rab. exs. n. 265 ! non Kuetz.; *Phorm. papyraceum* Rab. Fl. Eur. Alg. II, p. 125; *Chtonoblastus incrustans* Hilse in Rab. exs. n. 1956 p.p.; *Lyngbya Juliana β Paludinae* Wittr. in W. et N. exs. fasc. X, n. 492, Descript., p. 59; *Lyngbya Paludinae* Hansg. Prodr. II, p. 101; *Phormidium ambiguum* Gom., Setchell & Gardner, Algae of North-Western America, Univ. Calif. Pub. Bot. 1, p. 185, 1903; *Detoni Sylloge Algarum*, Myxophyceae, pp. 240-241, 1907; Tilden Minnesota Algae, Vol. 1, p. 103, Pl. V, fig. 5, 1910; Pascher, Sussw. Flora, Heft 12, Cyn. Geitler, p. 382, 383, fig. 482, 1925; P. Fremy, 'Algues, provenant des recoltes de M. Henri Gadeau de Kerville dans le canton de Bagneres-de-Luchon (Haute-Garonne)' p. 156, fig. 137,

1930; Rab. Kryptogamen Flora, Bend XIV, Cyan. Geitler, p. 1015, fig. 647e, 1932.

This species is also recorded by Prain from 'Salt Lakes, Calcutta' under the specific name *Phormidium Lyngbyaceum* Kg. which is synonymous to *Phormidium ambiguum* Gom., in his Vegetation of the Districts of Hughli, Howrah and the 24-Parganas (*Records of the Botanical Survey of India*, Vol. III, No. 2, p. 333, 1905). The wide range of distribution of *Phormidium ambiguum* from Europe to Africa and Eastern Asia to America clearly shows that this species is likely to be discovered also from various other localities in India. Out of the 85 species of *Phormidium* hitherto known to science only 28 species have so far been recorded from India.

During the examination of this algal material a narrow, very rapidly moving emerald-green *Euglena* sp., about 15–20μ long and 4μ broad with its long hyaline flagella, was detected under the microscope but it could not be killed and studied in detail. It is very likely that this species of *Euglena* was in a dormant stage in the algal matrix and renewed its vital activities after the application of warm water. Nothing definite can, however, be said about it with such superficial examination of an isolated single specimen.

I am much indebted to Mrs. H. P. V. Townend for her kindly collecting for me this interesting algal specimen and bringing it all the way from New Zealand.

HERBARIUM,
Royal Botanic Garden,
Calcutta, Jany. 12, 1942.

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ARTICLE No. 2.

Anatomical Studies on Indian Plant Galls—Part I.

By R. D. SAKSENA.

(*Communicated by Dr. K. P. Biswas.*)

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I. INTRODUCTION.

Galls are abnormal structures, either uni- or multi-cellular, on the roots, stems, buds, leaves or flowers of plants, arising as a result of the reaction of the plant to some kind of stimulus, produced by an external agent belonging to the Vermes, Arthropoda, Fungi and Bacteria. Gall formation on a plant often involves an abnormal growth and development or a retardation of the plant organ and with it is closely connected the nutrition of the gall-producing organism. While feeding on the plant body, the gall-producer stimulates the plant cells to increased activity and division and thus brings about an over-growth. Galls produced by different agents on different plants are characteristically different in structure not only externally but also anatomically.

Galls have been known from very early times to the Chinese and the Indians. They have been extensively studied in Europe and America by numerous workers like von Schlechtendal, Darboux, Kieffer, Rübsaamen, Trotter, Houard and others. The exhaustive works of Küster, Cosens and Ross are of special importance on account of their anatomical studies of galls.

Very little, however, has been done in India on plant galls. The early records of galls from India by Buckton (1889–1900), Kieffer (1905, 1908), Houard (1908) and others are often very incomplete. Later, Ramachandra Rao (1917, 1923) and Felt recorded a number of galls on grasses produced by gall midges. Ramakrishna (1924), Mani (1935) and Mathur (1935) recorded a

few plant galls produced by Psyllids. Numerous Indian galls were also included by Houard (1908) in his monographic work on the zoocecidia of Africa, Asia and Oceania. Some Indian galls were also recorded by Doctres van Leeuwen (1926) in their book on the galls of Netherlands East Indies. In 1924, Sundar Raman summarized all the available information on the insect and mite galls described from India. All these records of Indian galls are very incomplete and no case include an account of the anatomical characters. The first worker in India to turn his attention to a study of the anatomy of plant galls was Mani (1934–1939), whose systematic studies on the morphology and biology of several Indian gall midges and midge galls may be said to have laid the foundation of this subject in India.

In the present paper, which is the first of a series of studies on the anatomy of Indian plant galls, an attempt is made to describe briefly the anatomy of some common galls produced by Acarina and Diptera. This paper may be taken as a supplement to Mani's studies (*op. cit.*). In future contributions it is proposed to deal with the anatomy of galls produced by other agencies.

This study was undertaken by me at the suggestion of Mr. M. S. Mani, Imperial Agricultural Research Institute, New Delhi, who donated the materials and all necessary literature and also guided me in the work. My thanks are due to Dr. R. K. Singh, Principal, Balwant Rajput College, Agra, for facilities for work, for constant encouragement and for other courtesies. I am also indebted to the authorities of the Imperial Agricultural Research Institute, New Delhi, for permission to use the Imperial Pusa Library.

II. Material and methods.

The galls were collected during 1929–1933 in South India and Bengal by Mr. M. S. Mani and were fixed in formalin. Ross (1932) recommends the use of 50–70% alcohol as a fixative for plant galls meant for anatomical studies. Flemming's fluid consisting of 180 c.c. of 1% chromic acid, 25 c.c. of 2% osmic acid, 12 c.c. of acetic acid and 210 c.c. of distilled water may also be used. Best results were obtained with 20% solution of formalin. A more detailed account of the technique of preparing plant galls may be found in Schneider-Zimmermann (1922). The galls were then passed through graded alcohol, dehydrated in absolute alcohol, cleared in cedar wood oil and xylol and embedded in paraffin. Longitudinal and transverse sections were cut to an average thickness of 50–100 microns, stained in acid fuchsin or iron-alum haematoxylin and mounted in Canada balsam in the usual way. The photomicrographs were taken by Mr. M. S. Mani in 1936 and the line drawings were made by me with the help of camera lucida. Duplicates of the specimens of the galls dealt with in this paper are preserved in formalin in

the collections of the Zoological Survey of India, Indian Museum, Calcutta.

III. Acarina Galls.

The majority of the Acarina galls are produced by mites of the family Eriophyidae on different vascular plants and are divided by Küster (1911) into 'leaf margin curls', 'beutel gall or pouch galls' and organoid galls of different types. Zacher (1925) divides them into the histioide types of erinium, pouch galls, leaf rolls or fold, leaf deformations and into the organoid types of shape anomalies, branching anomalies, new growths and castrations. Besides the Eriophyidae, two other families of mites, viz., the Thrombididae and the Bdellidae also produce galls on plants.

Most of the mite galls are formed on leaves and flowers, though a few mites form galls on stems also. All mite galls have a more or less similar structure: they are usually pouch-like invaginations of the leaf, enclosing one or more cavities full of hairy outgrowths. The cavities always communicate with the outside by a minute hole, usually on the underside of the leaf. According to the external shape, mite galls on leaves are grouped into two classes: Ceratoneon and Cephaloneon galls. The anatomy of the cephaloneon type of pouch galls on leaf of *Pongamia glabra* Vent. is described below.

Pongamia glabra Vent.

Cephaloneon galls on leaves by *Eriophyes cheriani* Massee.[1]

As characteristic with mite galls on leaves, the large cavity of the galls (Fig. 1) is clothed with dense covering of tufts of long, golden-brown, slender, tomentose hairs. The narrow opening underneath is more densely covered by hairs than the wall of the cavity.

Epidermis consists of cells relatively smaller than in normal leaf. Cuticle is a little thicker than on a healthy epidermis. The stomata are normally distributed. The epidermis of the underside of the leaf, which in the gall lies on the inside and forms the invaginated wall of the gall cavity, is completely degenerated, devoid of chlorophyll and stomata. The cells have grown out into long (Fig. 2) unicellular hairs, rising in tufts from fleshy papillar projections. Each hair is about twenty times as long as thick, pointed, and devoid of protoplasm. The hairs on the narrow neck and near the opening are pointed downwards.

[1] Massee, A. M. *Ann. Mag. Nat. Hist.*, (10), XI, p. 201.
Mani, M. S. *Rec. Indian Mus.*, XXXVI, p. 425, (1934).

The tissue of the gall is about twenty to thirty times thicker than a normal leaf. It is mainly composed of small, subglobose, undifferentiated parenchyma cells, smaller immediately beneath the epidermis than elsewhere. The palisade and spongy parenchyma of a normal leaf are entirely absent in the gall tissue (Fig. 2) but the chloroplasts are more or less well distributed in the subepidermal layers of cells of the gall. Intercellular spaces are sparse in the middle tissue, while they are totally absent in the interior. The veins are completely degenerated and the vascular bundles composing them are scattered in the simple undifferentiated parenchyma of the gall tissue (Figs. 1 and 2) in an irregular manner. The number of vessels appear to be almost the same as in the normal part of a leaf. Tanniniferous cells are seen here and there in the parenchyma. The innermost layer of cells, just below the tomentose hairs, are actively proliferating cells. Very rarely dense tomentose outgrowths are formed from the epidermal cells of the gall on the outside. The normal leaves are not hairy and the development of hairy outgrowths in the gall is an instance of new tissue formation.

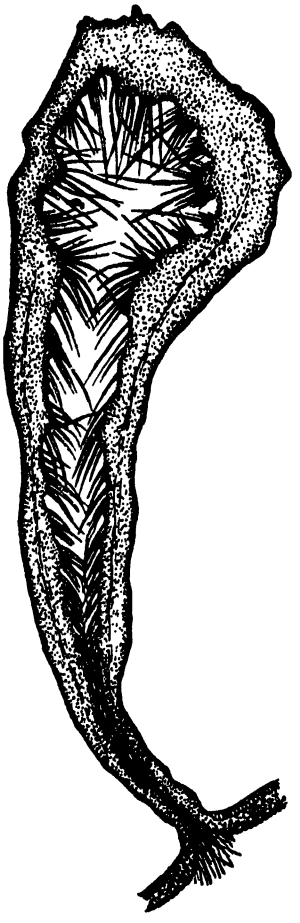


FIG. 1.—Longitudinal section of polypoid gall of *Pongamia glabra* Vent. (under low power).

IV. DIPTERA GALLS.

Among the Diptera only one family, Itonididae, is of importance as gall-producer. This family has extensively been studied in India by M. S. Mani (*op. cit.*). Most of the galls by Diptera are formed on parts of plant above ground; a few species produce galls on the roots of Phanerogams. The galls are of different types, viz. beutel galls (pouch galls), leaf margin galls, leaf curls, globose or fusiform swellings of stem, branch, leaf, or fruit. Most of the galls are of the histioid type, although a few organoid type of Diptera galls are also known. Other Diptera which produce galls on plants are *Anthomyia*, *Chlorops*, *Liparia* and *Agromyza*. In this

paper are dealt with the midge galls on stems, buds, leaves and flowers.

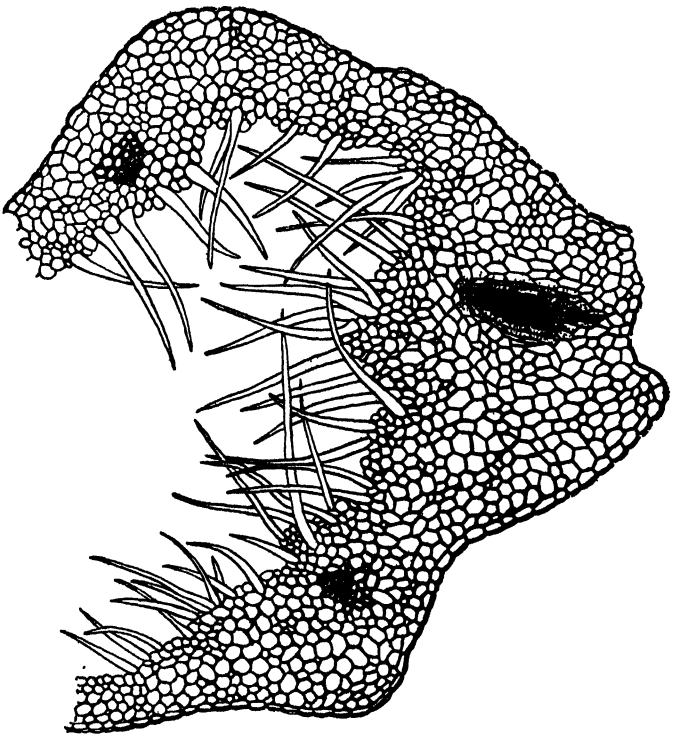


FIG. 2.—Transverse section of polypoid leaf gall of *Pongamia glabra* Vent. (under low power).

STEM GALLS.

Family—*Cucurbitaceae*.

Momordica charantia Linn.

Organoid galls on stem by *Lasioptera falcata* Felt.[1]

Ramakrishna [2] has figured the galls and the adult midges, but no description of the gall has so far been published. Organoid, hypertrophy; regular, oval, fusiform, often extensive tumescence of the vines, specially the tender ones; green or yellowish-green, densely villous, often longitudinally ribbed and

[1] Mani, M. S. *Rec. Indian Mus.*, XXXVI, p. 394, (1934).

[2] Ramakrishna, T. V. *Rep. Proc. Third Ent. Meet.*, I, p. 324, pl. xviii, figs. *a*, *b*, (1920).

sulcate; sometimes contorted and branched. Leaves often stunted and tendrils reduced. Solid and fleshy. Larval tunnels longitudinal, two or three in number. Size usually 2 cm. in maximum diameter and 4·5–6 cm. long. Sometimes a whole internode is converted into a gall but very often three-fourth of an internode is swollen.

Figure 3 shows a transverse section of the gall in the middle. Epidermis normal, epidermal covering of long hairs also normal. Parenchyma of the cortex with relatively larger cells. Chloroplasts distributed in the subepidermal layers of cells. Distribution of vascular bundles almost as in normal stem, except that the medullary rays are broader and as a whole the bundles lie

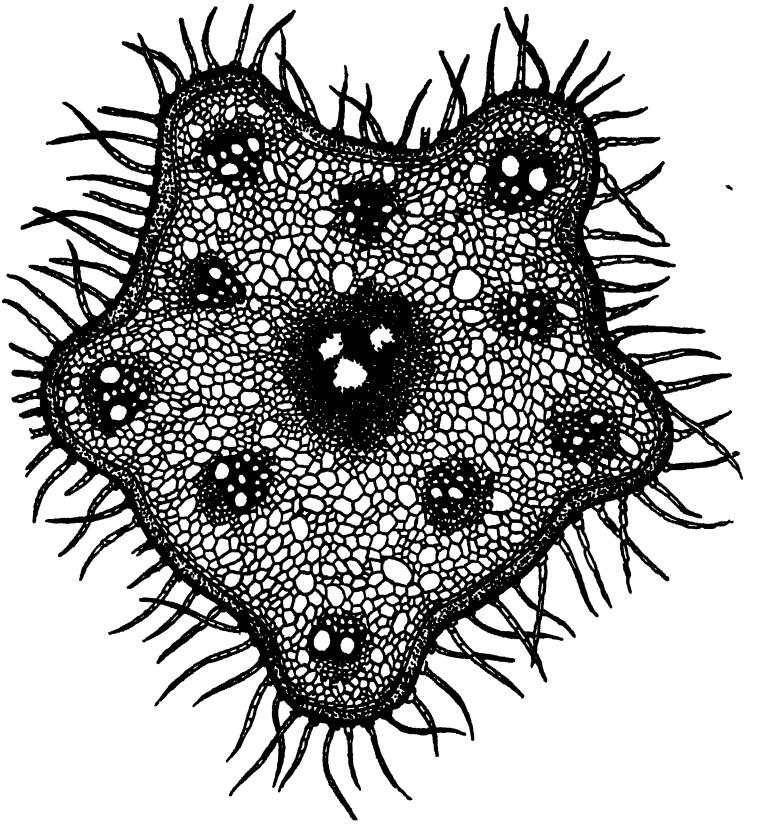


FIG. 3.—Transverse section of shoot gall of *Momordica charantia* Linn. (Redrawn from a photomicrograph by Mani, under low power.)

closer to the epidermis than to the medulla. In the centre of the parenchymatous mass, surrounding the narrow larval tunnel,

is a mass of small, closely-packed proliferating cells. The seat of cell proliferation thus lies in the medulla of the stem.

The anatomical structure of this gall differs from the similar stem galls of *Coccinia indica* (produced by *Neolasioptera cephalandrae*) (vide infra) in the absence of the cystiferous thickening of the larval tunnel, in the scattering of the vascular bundles being less complete and in the cell proliferation being confined to the medulla only.

Melothria maderaspatana Cogn.

Shoot gall by *Lasioptera* sp.

Mani [1] described a shoot gall on this species under the name *Mukia scabrella* Arn.

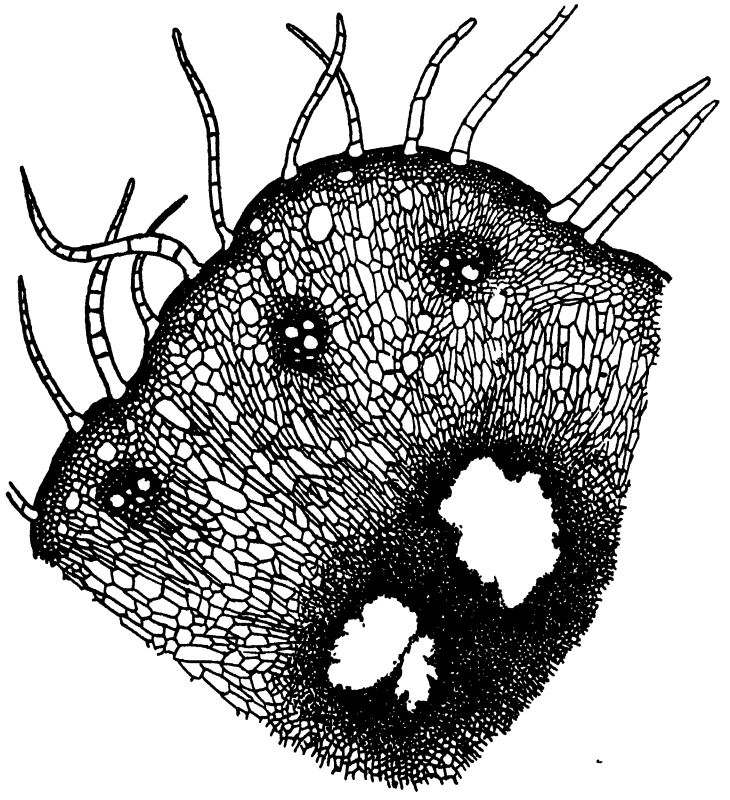


FIG. 4.—Part of transverse section of shoot gall of *Melothria maderaspatana* Cogn. (Redrawn from a photomicrograph by Mani, under low power.)

[1] Mani, M. S. *Rec. Indian Mus.*, XXXVII, p. 450, (1935).

Figure 4 shows a part of the transverse section of the gall under low power of the microscope. Epidermis is normal. Vascular bundles are relatively more irregularly scattered than in the gall of *Momordica charantia*; epidermal cells more abundant than in a normal part of the stem. Cortical tissue comparatively less than medulla, which is the seat of cell proliferation. Parenchyma cells large, regular and hexagonal in shape near the epidermal side but smaller in the interior, gradually merging into the layer of proliferating cells in the very middle. The seat of cell proliferation is the medulla.

Coccinia indica W. & A.

Shoot galls by *Neolasioptera cephalandrae* Mani.[1]

This gall was first described by Mani from South India and has since been recorded by him practically from all over India. The galls are fusiform, oval, local or extensive moniliform swellings of the vines. A transverse section through the middle of the gall shows the highly characteristic larval cyst, surrounded by a layer of closely packed small cells with thick walls, with the parenchyma outside. The thickening of the cell walls surrounding the larval cavity has been described by Mani[2] as cyst-formation. Outside the cyst is an irregular layer of proliferating cells.

The epidermis is quite normal, though most of the epidermal cells are somewhat smaller than in the normal stem. The sub-epidermal cells contain much less chloroplasts than in healthy stems. An extensive parenchyma consists of smaller or larger hexagonal cells. (Plate II, fig. 2.) The vascular elements occur irregularly in the parenchyma. A large vascular bundle is visible in the figure at one end of the larval cyst. There is no differentiation between cortex and medulla.

Bud Galls.

Bud galls are produced by mites, thrips, coccids and sometimes by midges. In most cases bud galls are of the organoid type and consist of a simple hypertrophy of the component parts. In some cases, however, especially those produced by gall midges, they are histioid and involve very considerable anatomical modifications of the leaves, and sometimes even of the growing axis of the bud. The leaf bud gall of *Crataeva religiosa* Forst., may be taken as typical of a bud gall produced by a gall midge.

[1] Mani, M. S. *Rec. Indian Mus.*, XXXVI, p. 397, fig. 9, (1934); *ibid.*, XXXVIII, p. 193, (1936); *ibid.*, XL, p. 331, (1938).

[2] Mani, M. S. *Curr. Sci.*, II, p. 18, (1933).

Family—*Capparidaceae.*

Crataeva religiosa Forst.

Bud gall by *Cecidomyiella crataevae* Mani.[1]

The galls are irregular, sub-pyriform, fleshy, lobed swellings of the leaflets of an entire bud. The whole mass of the gall is composed of undifferentiated parenchyma cells of small size. In plate I, figs. 1 and 2 are shown respectively longitudinal and transverse sections of a part of the fleshy lobe of the gall. The mid-rib is seen to be normal, while the laminar portion of the leaflet on either sides of it have become completely converted into the undifferentiated parenchyma of the gall. The epidermis has practically disappeared. The text-figure 5 shows a part of the fleshy lobe of the gall, with some portion of the normal

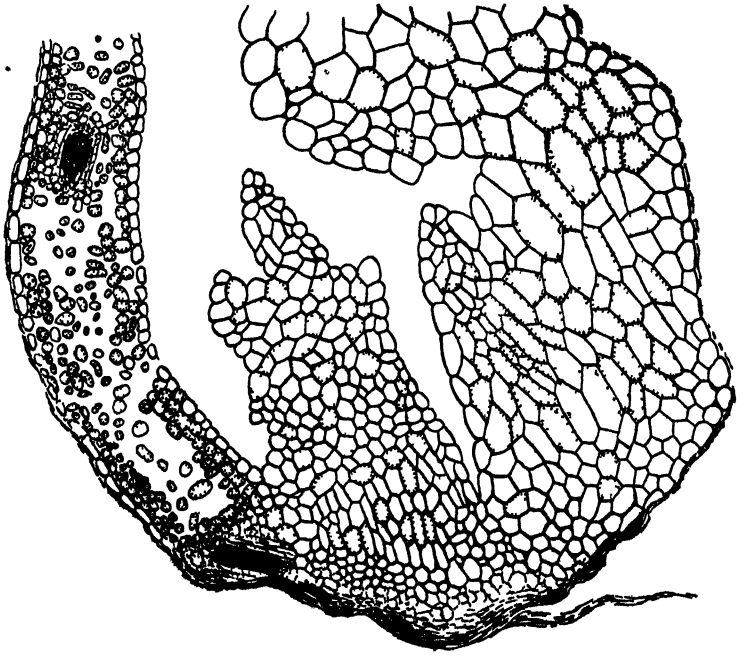


FIG. 5.—Transverse section through a part of the fleshy bud gall of *Crataeva religiosa* Forst. (under low power).

lamina still on one side. The sharp contrast between the differentiated parenchyma in the normal lamina and the large

[1] Mani, M. S. *Rec. Indian Mus.*, XXXVI, p. 428, (1934).

cells in the undifferentiated parenchyma of the fleshy mass of the gall is very prominent. The apical part of a lobe of the gall consists of smaller cells than the interior, owing to the fact that cells in this region are actively proliferating. This is shown under higher magnification in text-figure 6. The vascular elements are normal but deeply embedded and scattered. Only

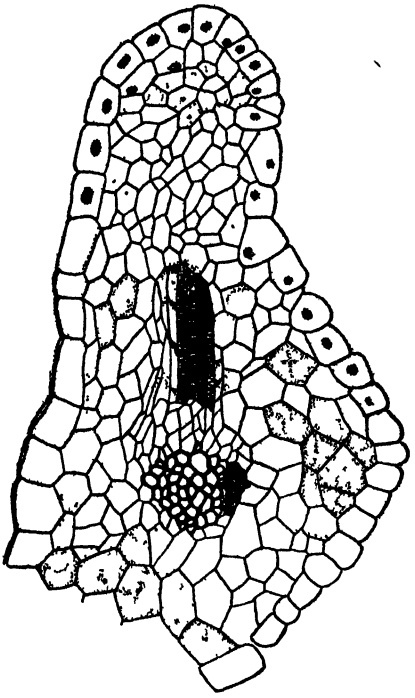


FIG. 6.—Longitudinal section of a fleshy lobe of bud gall of *Crataeva religiosa* Forst. near tip (under low power).

a few layers of cells immediately below the surface of the gall contain chlorophyll. The centres of cell proliferation lie in the mesophyll of the leaflets and cortex of the terminal axis of the bud.

LEAF GALLS.

Most of the galls on petioles and leaf blades produced by Diptera are solid structures, usually of the histioid type. Some pouch galls are also formed on leaf blades by midges.

Family—*Anacardiaceae.*

Odina wodier Roxb.

Galls on petioles and leaf veins by *Odinadiplosis odinae* Mani.[1]

Epidermis is normal but in many places covered by scaly layers of cuticle. The subepidermal cells are somewhat oblong and small, while in the interior the cells are more rounded and

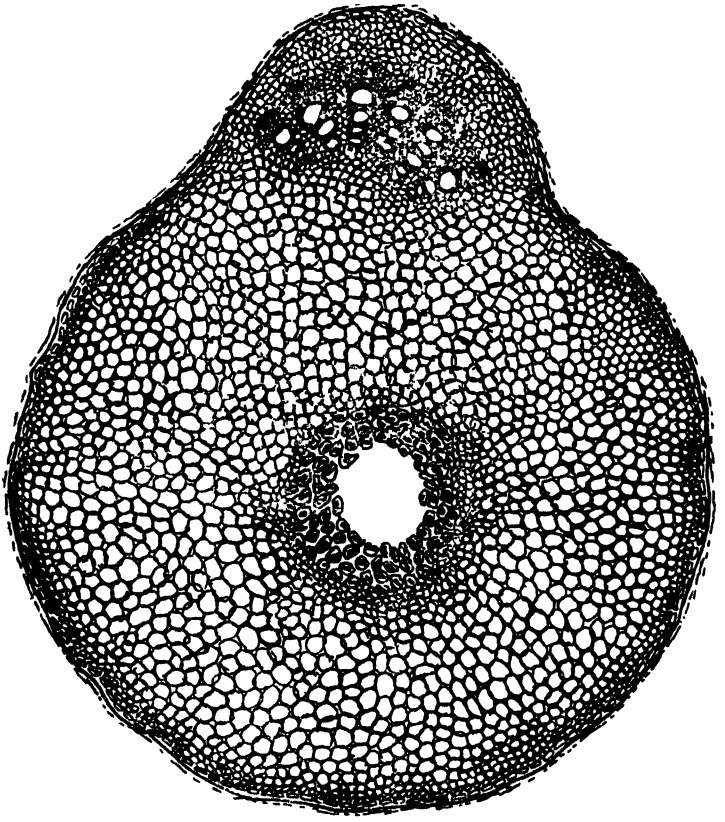


FIG. 7.—Transverse section through a 'Rindengall' of petiole of *Odina wodier* Roxb. (Redrawn from a manuscript figure by Mani (under low power).)

larger. The parenchyma is otherwise undifferentiated. Larval tunnel is surrounded by a cyst of thick-walled cells outside of

[1] Mani, M. S. *Rec. Indian Mus.*, XXXVII, pp. 435–439, (1935).

which is a layer of proliferating cells. When the gall forms as an outgrowth on the petiole, the seat of cell proliferation lies in the cortex and the vascular bundles of the petiole remain normal (Fig. 7). This type of gall is usually called 'Rindengall' (Ross, 1932).

Family—*Leguminoseae*.

Pongamia glabra Vent.

Leaf vein gall by *Myricomyia pongamiae* Mani.[1]

The galls are irregular and extensive tumescence of the veins of the leaf. A transverse section (Plate I, Fig. 3, under high power) of the gall characteristically resembles a transverse section of a monocotyledonous stem, with the vascular bundles open, isolated and scattered among the undifferentiated mass of small, regular, hexagonal parenchyma cells. The epidermis is normal but without the usual thick cuticle. Chloroplasts are entirely absent in the gall tissue.

Family—*Convolvulaceae*.

Rivea hypocrateriformis Choisy.

Spongy leaf gall by *Asphondylia riveae* Mani.[2]

The galls are large, globose or egg-shaped solid spongy swellings of the leaf blades, arising as a result of extensive cell proliferation of the entire tissue of the leaf on either sides of the mid-rib. The leaves are folded along the mid-rib while in the bud and the eggs are laid by the adult midge between the folds. The larvae on hatching start feeding on the cell contents and set up cell proliferation, as a result of which the two halves of the blade fuse together and swell up very much. The fusion thus naturally takes place on folded side, i.e. along the upper side of the normal leaf, so that the outer surface of the gall is in reality the under side of the blade. Cell proliferation does not always extend to the entire mass of a lamina but often portions are left normal on the gall. Transverse sections through this region clearly shows the characteristic gradual degeneration of the palisade cells into the undifferentiated spongy parenchyma of the gall (Text-figure 8, Plate II, Fig. 4). Plate II, figure 1, shows a part of the transverse section of the gall near the mid-rib.

[1] Mani, M. S. *Rec. Indian Mus.*, XXXVI, pp. 420–422, fig. 18, (1934).

[2] Mani, M. S. *Rec. Indian Mus.*, XXXVI, pp. 411-412, (1934).

The bulk of the gall tissue is made of large spongy parenchyma like cells with considerable air-spaces between.

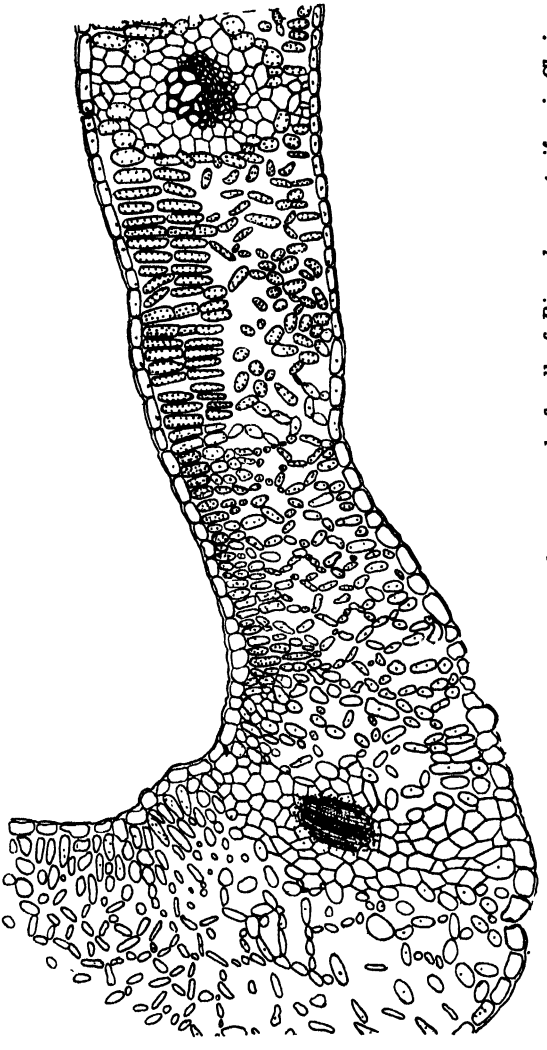


FIG. 8.—Transverse section through a part of the spongy leaf gall of *Rivea hypocrateriformis* Choisy, with a part of the normal leaf blade on the right, showing the gradual disappearance of palisade (under low power).

The epidermis is quite normal, but the fine silky hairs common on the under side of a normal leaf are completely absent. The subepidermal layers of cells contain some chloroplasts but the rest of the cells are wholly devoid of the green colouring matter. Deep in the interior surrounding the irregular, oval larval

chambers are smaller, closely-packed proliferating cells. A true cyst is not found in this gall. The veins of the leaf have become degenerated and the vascular bundles composing them are irregularly scattered in the spongy mass of the gall.

A careful study of the text-figure shows that at the seat of gall formation the palisade cells gradually become smaller and smaller, the spongy cells more numerous and larger until finally in the gall there is no differentiation of tissues.

In his brief account of the morphology of this gall, Mani (*loc. cit.*) described the subepidermal layers of the spongy parenchyma of the gall as becoming elongated and taking on the function of the true palisade cells, which have degenerated in the interior of the gall. My studies have not borne out his view. Although the subepidermal cells in the gall contain some chlorophyll and are thus capable of functioning as assimilating tissues, no trace of elongation of the cells is visible anywhere.

Family—*Leguminosae.*

Acacia leucophloea Willd.

Tomentose leaf gall by *Schizomyia acaciae* Mani.[1]

The adult midge lays eggs in between two-folded leaflets and the larvae on hatching start feeding on the cells nearby. This sets up extensive cell proliferation and the two leaflets fuse together into an oval gall, with narrow part of the blade still left normal, especially at the tip. A dense tomentum of brown, unicellular hairs grows on the surface of the gall.

The bulk of the gall tissue (Figs. 9*a*, 9*b*) is made of regular, hexagonal, undifferentiated parenchyma cells, full of chlorophyll and tannin. The epidermis is very characteristic and is shown very highly magnified in Fig. 9*c*. The cuticle is thick, epidermal cells are small and project outwards as shown in the figure. There are no hairs on the normal leaflets, except for a little fine pubescence on tender ones. The appearance of the tomentum on the surface of the gall is formation of tissues (Cosens, 1912). The palisade and spongy parenchymae have become completely degenerated in the gall. In the centre of the mass is a large oval larval cavity, surrounded by a moderately thick layer of small, very closely packed proliferating cells, without the green colouring matter and thus very conspicuous in a section. All the veins are degenerated and the vascular bundles composing them are scattered in the form of a broken ring in the gall tissue.

[1] Mani, M. S. *Rec. Indian Mus.*, XXXVI, p. 406, pl. vii, fig. 1, (1934).

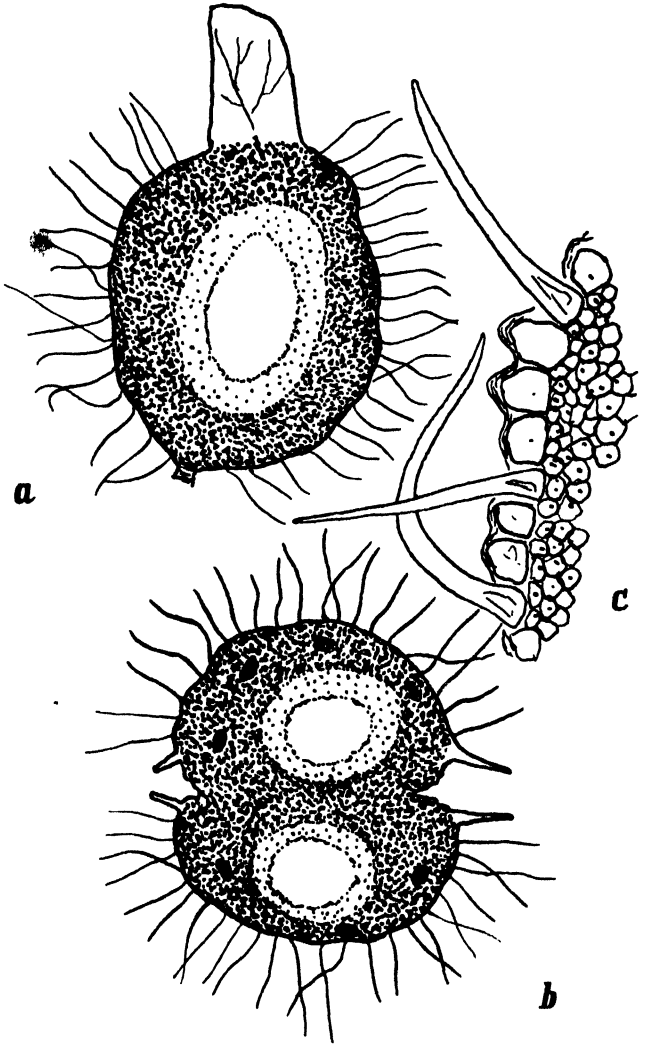


FIG. 9.—Tomentose gall on leaflets of *Acacia leucophloea* Willd. (*a*) longitudinal section; (*b*) transverse section (under a hand lens); (*c*) epidermis and hairs (under high power). (Redrawn from a photomicrograph by Mani.)

FLOWER GALLS.

The simplest type of flower gall consists in the suppression of the essential organs of a flower or in the entire flower. Very

often one or more of the floral envelopes become converted into green and leaf-like structures. Such a type of gall is usually called 'phyllomany'. When the growing points in the floral axis persists and all the floral envelopes turn into green leaf-like organs, even producing branches from their axils, the original floral nature of the growth cannot be recognized. This type of development is called 'Wirrzöpfe'. When this developmental degeneration involves even the essential organs of the flower, the resulting gall is called 'chloranthy'. In many cases galls are formed on the peduncle or pedicel. The bulk of the flower galls produced by midges are however of the histioid type and bring about extensive cell proliferation of one or more of the floral parts with swellings and complete loss of the characteristic features of the organs. The flower gall of *Ipomoea sepiaria* is very characteristic in that the entire flower bud becomes a large, globose, swollen mass, in which no trace of any of the floral parts can be seen.

Natural order Convolvulaceae.

Ipomoea sepiaria Koen.

This gall is produced by an unknown species of gall midge and was recorded by Mani from South India. The following is a full description of the gall: Histioid, subglobose, irregular, solid, fleshy, lobed and tubercular, pale yellow or brown swellings of the entire flower bud, about 15–25 mm. in diameter. The calyx is hypertrophied. The other parts of the flower are completely degenerated into a huge mass.

Plate II, Figs. 3 and 4 show respectively transverse sections of normal flower bud near the tip and a part of a gall. There is no true epidermis. The tissue consists entirely of small undifferentiated parenchyma cells. There are two larval cavities visible in the section and surrounding them is a layer of small proliferating cells. The vascular elements are scattered. Cell proliferation takes place in tissue of the petals, stamens and ovaries. The cells of the galls are somewhat larger than in the normal floral parts.

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FIG 1 Longitudinal section of fleshy gall of *Crataeva religiosa* Forst, showing a part of the fleshy lobes and a vein (under low power)



FIG 3 Transverse section of *Pongamia glabra* Vent showing the vascular bundles scattered irregularly in the undifferentiated parenchyma as in a monocotyledonous stem (under low power)



FIG 2 Transverse section of the same showing mid rib and the fleshy lobes of undifferentiated parenchyma (under low power)



FIG 4 Transverse section of spongy leaf gall of *Bauhinia hypocrateriformis* Chowdhury, showing the gradual disappearance of palisade and general structure of the spongy mass of gall (under low power).



Transverse section of spongy leaf gall of *Reca hippocrateriformes* Choisy on the lower side showing the mid rib and a part of the parenchyma of the gall (under low power)



FIG 2 Transverse section of a part of solid shoot gall of *Coccinia indica* Cogn showing larval cyst scattered vascular bundles, proliferating cells and large parenchyma cells (under low power)



FIG 3 Transverse section of flower bud (at tip) of *Ipomoea sipiaria* Koen (under low power)



FIG 4 — Transverse section through a part of the fleshy flower gall of *Ipomoea sipiaria* Koen, showing the irregular fleshy lobes, two larval cysts surrounded by proliferating cells and the undifferentiated parenchyma (under low power)

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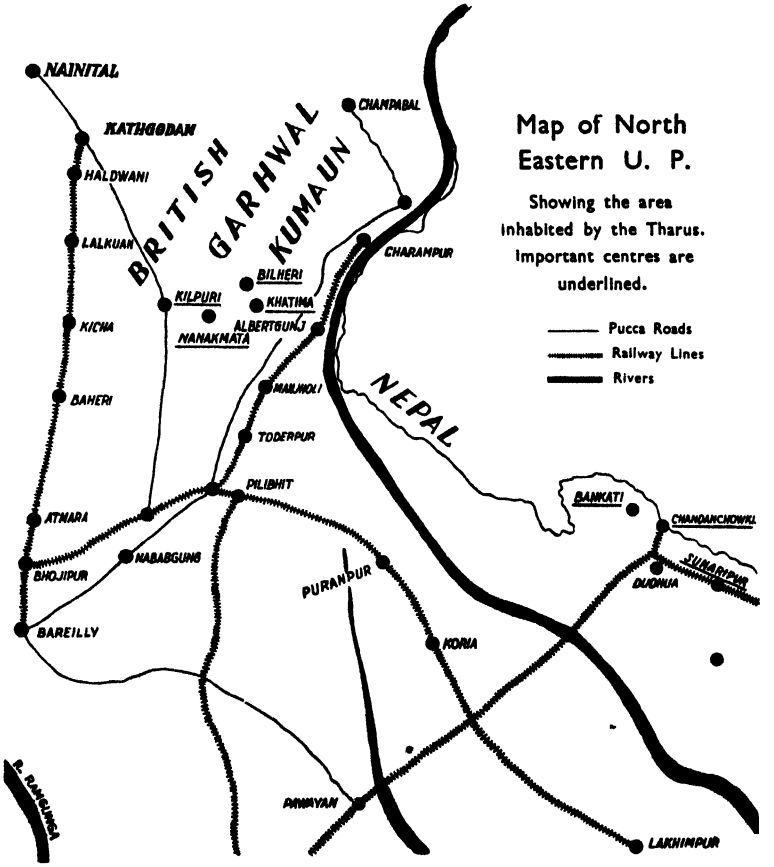
Volume VIII, 1942.

ARTICLE No. 3.

The Tharus and their Blood Groups.

By D. N. MAJUMDAR.

The Tarai extends across the length of the Himalayas fringing the densely populated plains in the south. It is a low land of morasses and fens mostly covered with thick forests where wild beasts and jungle fever abound to make the country unsafe for settlement. Here dwell the Tharus and Bhoksas, two primitive tribes, who have either migrated for safety or have



been living in their secure asylum for centuries. The Tharus and Bhoksas are most interesting to ethnologists as both have maintained many of their primitive customs and traits in spite of their recent contacts with advanced social groups. The Bhoksas are found dovetailed between the Tharus in the Tarai and Bhabar from the Nainital-Pilibhit district border extending westwards across the north of Bijnour district and the south of Garhwal to the Ganges. The total Tharu population as recorded in the 1931 census is 77,021, of which 40,288 are males and 36,733 females (1931 Census, Vol. I, pt. II, p. 523). The distribution of the Tharus province-wise is as follows: Bengal 482, Bihar and Orissa 37,338 and U.P. 39,201. In the Nainital district of the U.P., there are 30,753 Tharus and 6,600 Bhoksas. The Nainital Tharus are found in the following places: Bilhari, Nanakmata, Kilpuri and Tanakpur, but the majority are found in the Khatima Tehsil, which includes the whole of Bilhari Perganah, a part of the old Nanakmata, a part of Kilpuri and Tanakpur. In the Kheri district in U.P., the Tharus inhabit the northern areas bordering Nepal, from Bilraian to Bankati and even beyond. They are found on either side of the river Sarda, in British India and Nepal.

There is little doubt that the Tharus and the Bhoksas belong to the same ethnic stock and it is perhaps true that both of these groups had come to the Tarai at the same time. The little difference in their culture should be attributed to the process of tribal transformation which must have taken place in their present habitat. It is possible that one group joined the ranks of Hinduism earlier than the other. The stories about their origin, the traditions the people still remember, do not give any clue to their affiliation or difference The Bhoksas say that they came from Dakshin or the south; some among them believe that they have come from Delhi, others that they were Panwar Rajputs and under Udayjit came to live at Bonbassa on the Sarda. Udayjit rendered valuable services to the Raja of Kumaon who gave them shelter. We shall discuss this aspect of their prehistory in another connection.

Culturally the Bhoksas are more advanced than the Tharus; they engage Brahmins to officiate in their marriages, and put on sacred thread like caste people. The Tharus allow divorce and remarriage of widows, the Bhoksas look down upon such practices. The Tharus are a devil-ridden people, have oaths and ordeals in plenty and much of their disputes are settled through them, while the Bhoksas have lost their faith in such expedients. Witchcraft is a special characteristic of the Tharus and so great is the belief in their magical powers that the other people who come to trade with them dare not come too near their villages. The Bhoksas do believe in magic and witchcraft but they do not practise these arts, but leave them to the Tharus who are consulted in times of crises.

Dominance of women in Tharu Society.

The Tharu women have a dominant position in the society. They form 90 p.c. of the crowd in markets and fairs. The women move about freely, and even smoke and drink in the bazar. Fishing is a feminine occupation and outdoor activity such as marketing produce, buying and selling, and business negotiations are also done by women. The acknowledged superiority of women among the Tharus has been the subject of much speculation and widely divergent views are held by scholars who have written on them. The Tharu women do not allow their husbands to touch food or enter the kitchen. They do not allow the men to touch the water pots wherein water for drinking is stored. The women are expert painters and decorators; they paint pictures and scenes depicting fights and warriors on horseback. The women fish and hunt; the men carry traps and receptacles. In the Census Report of the U.P. (1931) further peculiarities of Tharu women are recorded. While the caste women proceed to the fields, very early in the morning, have a meal at mid-day and work till the evening, the Tharu women go to their fields after a good meal corresponding to English breakfast. At mid-day they eat some grain and then return home in time to prepare the evening meal for their menfolk. They thus work two to three hours less than women of other tribes and castes. Again, Tharu women unlike other women do not carry paddy seedlings to the fields where they have to be transplanted; the seedlings have to be carried by men. Other women carry them on their head thus saving the expense of a labourer or two. Local landlords did their utmost to change these conditions but rather than change their mode of life the Tharus chose to leave the fields altogether. The result was an emigration of the Tharus to Nepal and adjacent parts where they live by agriculture or by engaging themselves as labourers.

The tribal code definitely lays down the share of each sex in the property and belongings of the tribe. Women are the sole proprietors of domestic pets, poultry, cattle and the produce of the kitchen garden. They can dispose of these in any way they like and can use the income for their own personal needs. On one occasion a Tharu was tempted to sell a cock to my peon who was collecting provisions for me in the Tanakpur area. The Tharu brought the bird covered all the way to deliver it to my cook personally and realized the price for it. It was not the usual price he charged; he most certainly included consideration for his labour and the mental worry involved in appropriating other people's property, as I came to know later on. In the evening all the neighbouring villages were invited by me to my tent for a demonstration of Tharu dance and music. The wife who owned the cock was also an expected

visitor. When the villagers started for my camp the man who had sold the cock to my peon ran up to my camp before the others arrived and demanded back his cock. My cook did not realize the implications of this demand and began to howl at the man, threatening him with dire consequences should he persist in his efforts to recover the bird. Fortunately, the cock was not meant for dinner that night and this lease of life saved the Tharu from abject exposure before the villagers. I was attracted by the *'golmal'* and enquired from the Tharu what his grievance was. He narrated the story of his discomfiture; how he has sinned against his wife and how he wanted to make amends for it. I ordered the release of the bird and the return of the 'prodigal ward' at once beamed up his frightened face and a glow was seen in his small covered eyes. What would have been a very delicate situation was remedied and a domestic quarrel which might have broken the ties of their marital life was averted.

While the women have their belongings, the men have their bird traps, ploughs, oil presses, the rewards of their manual labour and the produce of their fields. Even if they own these, they are not free to dispose of them as they please, for they need to consult their wives whose advice they seldom dare ignore. Ill-treatment of husbands by wives is frequent in the Tharu country and very often the aggrieved husband has to approach the Bharara (tribal priest) and through him offer prayers and sacrifices to their gods and goddesses for redress of his sufferings. The women are often seen as hard task masters and their direction of the activities of their menfolk is not always above reproach. But men have accustomed themselves to the ways of their women, and have adapted themselves to the condition of life, and the jealousies and suspicions their women excite in them find expression in their belief in magic and witch-craft and in the various protective devices, charms and amulets, which aim at securing for them a decent livelihood and domestic bliss, a rare privilege of Tharu family life.

The dominance of women in the Tharu country is explained by the tradition that the Tharus are offsprings of mixed marriages between Rajput women and their servants, 'Saises' and 'Chamars' with whom the former fled to the jungles to escape the invading armies who killed their king and his men, their husbands and relations. The tradition is supported by the Tharus on the ground that the Tharu women have better physical features than men and they have consistently upheld the ban on the liberties of their menfolk, in spite of contacts with outsiders and the gradual progress they have made in their cultural life. It is true the Rajputs are taken as the progenitors of most of the Hinduized sections of the primitive substratum of population in India. Risley has described the various processes of tribal transformation and has shown how in all these processes the historical element has been supplied by the Rajput families of

Northern India who were believed to wander about and take shelter in inaccessible and even inhospitable regions to escape the lot of serfs and slaves in their native land, as the Mahomedans began to reduce one after another the independent Rajput principalities of Northern and Central India.

Writing about the physiognomy of the Tharu tribe, Nesfield said that the tribe had acquired a slightly Mongolian caste which showed itself chiefly, but not to a striking degree, in slanting eyes and high cheek bones. This he traced to intermarriages which have taken place within the last two or three centuries. But the description he gives of the average Tharu does not seem to be correct. He writes, 'They (the Tharu) have long wavy hair, a dark, almost a black complexion and as much hair on their face and body as is usual with other natives of India. In stature, build and gait they are distinctly Indian and not Mongolian; nor have they any traditions which connect their origin with Nepal.' Risley recorded evidence of Mongoloid traits among the Tharus and Knowles found the 'mongolian style of feature', predominant among them. According to Crooke, 'the most probable explanation based on the available evidence seems to be that the Tharus are originally a Dravidian race who by alliance with Nepalese and other hill races have acquired some degree of Mongolian physiognomy'. That the Tharus have Mongolian features there is hardly any doubt. Their eyes are oblique, their complexion yellow or yellow-brown, hair on the body and face very scanty and straight, their nose thin and of medium size, while other features affiliate them more with the Nepalese than with any australoid or pre-Dravidian tribe or caste. I should think that the Tharus are really a mongoloid people who have assimilated non-mongoloid features—but how much of these are made up of the australoid or pre-Dravidian element and how much by the Rajput type requires further investigation.

Although the Tharu women possess a number of privileges which are usually denied to women of other tribes and castes, and they are more handsome than men, the suggestion of a Rajput strain among the Tharus is not easy to prove. In a few cases we have found regular features, horizontal eyes, high forehead, tall stature and sallow white complexion, but these could be traced to mixed marriages whose memory has not died down in the villages. The cultural life of the Tharus does not suggest any super-imposition of a higher culture on their indigenous pattern of life and living and those traits that appear alien are the result of contacts with foreign elements in the local population. Besides, in cases of mixture between a higher and an inferior race, a sort of hypergamy is practised, and an endogamy develops after a *Jus Connubii* is effected. For a time only hypergamous marriages are allowed till the barriers become rigid enough to bar any further inter-mixture. That may have

been the cause of the origin of a large number of endogamous groups in India; it is also the case in other countries where such mixture has taken place. The frequent marital raids of the Tharus to Nepal from where they secure their supply of women do not support the contention of the comparative purity of race among the Tharus nor do the Tharu women prefer marriages with caste people among whom they live.

The other plausible explanation of the dominance of women among the Tharus may be the natural aversion of men to do any work as is found generally among some mongoloid tribal stock. The mongolian is often found to be sluggish, weak, irresponsible and unwilling worker and in many areas they live on the labours of their wives. This may have pushed the Tharu men into the background while the women have assumed greater and greater responsibility in domestic life, till to-day they wield considerable influence over their menfolk. But even this explanation, I think, is not enough, for responsibility in domestic life may not result in undue importance of the womenfolk. The Tharus unlike other mongoloid tribes are a strong people. Their physical powers and habitual attitudes exhibit their capacity for sustained work, untiring endurance and strenuous efforts. The women appear to be rather delicate in constitution yet they are very brave and help their menfolk in the chase, which is still an important occupation with them. The Tharus are excellent cultivators and will 'till about four times as much land as a plainsman in the same neighbourhood'. The dominance of women, their rights to property, their maltreatment of their husbands, their active rôle in fishing and the chase and also in business negotiations, their liberty in choosing their partners and annulling marriages, all reproduce the conditions of a matriarchal society, and it is desirable to investigate how far the Tharus have in them foreign racial traits which has been seized by zealous social reformers as the explanation of their culture pattern or how the Tharu culture of to-day exhibits survivals of a matriarchal stage. This highly interesting aspect of Tharu culture tempted me to study their racial traits and anthropometric measurements, and blood groups were taken from various Tharu centres. The anthropometric data are being analysed by Prof. P. C. Mahalanobis at the Statistical Laboratory, Calcutta, the results of which will form the subject of a report to be published by the Government of India, Census Operations, 1941. The blood groups data can be discussed without prejudice to the work in progress.

The Incidence of Malaria among the Tharus.

Another reason that prompts me to discuss the blood groups of the Tharus is their comparative immunity from malarial fever. The Tharus, living as they do in a malarious and

unhealthy country, have been popularly known as immune from malarial infection. As early as 1904, Mr. H. R. Nevill mentioned this fact in the district Gazetteer of Nainital. 'From habituation', so he writes, 'and from a long course of natural selection, the Tharu has become almost immune from the deadly malarial fever of the Tarai. It is not true, as is usually asserted, that the Tharu never suffers from fever, but it is an undoubted fact that he is able to live and flourish in a climate which is generally fatal to emigrants from other districts.' But the Tharus suffer from an eye disease called trachoma which is found in an epidemic form. Boys and girls otherwise handsome and healthy most have their eyes affected with trachoma and often the pupil is seen dilated and even bulges out which add to the volume of the eye folds. The Tharus were also the subject of a report about 30 years ago and their immunity more or less was recognized by the Public Health Department.

How far malaria is selective would be an interesting enquiry. Some correlation between malaria and blood groups was observed by Russian scientists. The Tarai, as we have already mentioned above, is notorious for the incidence of malaria and yet there are people who live and thrive in the unhealthy and inhospitable climate of the Tarai. People who are not habituated to the climate suffer from malaria and in some parts like Chandan Chowki, Dudhwa, Bonbasa and Tanakpur, the incidence of malaria is very high. In Bonbassa where the head works of the Sarda Canal lie, the incidence of malaria among the labour population is so high that the authorities had to devise methods to protect the labourers from malarial infection. Not only was a regular dose of quinine systematically given to the people, but a big house with wire guaze fencing was constructed and as soon as the labourers finished their daily routine duties, they were made to enter the house and remain there till next morning when they would again be harnessed to their respective duties. Those that chafed at this preventive measure were forcibly put into the shed and locked inside, an arrangement, however cruel it might look was necessary in the interest of the work and also of the workers concerned.

Malaria is one big single cause of depopulation in many parts and of loss of vitality in the population, but in the Tarai among the Tharus and Bhoksas, the ravages of the disease have been insignificant compared to those in other parts of India. Onions and garlic in large quantities in their diet are considered to be the cause of immunity from malaria by some; while others claim their immunity from their habitual cleanliness and the full meal they get always. It is difficult either to accept or reject these explanations but even if they be true, similar immunity must develop elsewhere among people who suffer from malaria.

Our enquiries have shown that the Tharus have not developed an absolute immunity from malaria. The Tharu children suffer

from the disease as much as other children. I should think that ninety per cent of these children show their spleens in no uncertain manner. But as the children grow the spleen gradually gets reduced and ultimately become normal and by the age of 12 to 15 the Tharu children develop an immunity. This experience has been corroborated by medical officers of health who have worked among the Tharus and also the local people who know them so well.

The Blood Groups.

The Tharu data were collected from various villages round about Chandan Chowki, Dudhwa, Bankati, Bilraian, Sonarpur in the North Kheri Forest Division and from Bonbasa, Tanakpur and Nanakmata in the Nainital District. The anthropometric measurements and blood group data discussed in the paper were obtained, with the kind help of Mr. N. Sen, I.F.S., Divisional Forest Officer, North Kheri division who had accompanied me in my tours and also assisted me in my work throughout my stay in the Kheri forests. The photography, as usual, was done by my friend Mr. P. R. Roy, the reputed artist who voluntarily accompanies me in my ethnographic tours. I am indebted to Roy for generous co-operation and to Mr. Sen for the valuable facilities without which the data could not be secured.

The group sera were made at Lucknow by Dr. V. S. Manglik and as usual were tested against Sera from the Haffkine Institute, Bombay, and those from the Central Research Institute, Kasauli. The laboratory paraphernalia were conveniently carried in a portable trunk and the difficulties of field work were considerably obviated. Tents were pitched in the centre of Tharu villages and where bungalows were available, the Tharus were asked to assemble ostensibly for medical inspection. The local medical officer of health also accompanied me and assisted in the collection of blood samples and his presence and that of the D.F.O. made the work smooth for me and pleasant to the Tharus. So anxious were the women and the children for getting their blood tested that hours before we reached a village centre they were present in numbers for the purpose. Many had to be disappointed as I could not test more than a limited number every day and those that went unexamined had to be satisfied by presents, cigarettes and coins. I don't think if any investigator had similar fortune as I had among the Tharus. The usual precautions, testing the potency of the sera to be used, controls, etc. were taken. Blood was taken from the fore-finger of the left hand with a prick by a blood taking lancet and poured into small sterile test tubes with cotton plugs and containing 1 c.c. normal saline prepared fresh every morning.

Before testing, the supernatant fluid was poured off each deposit of red cells and saline was added to give an even sus-

pension. As the samples were tested two to three hours after collection, few cases of haemolysis occurred.

The table below gives the blood groups of the Tharus and Tibetans:

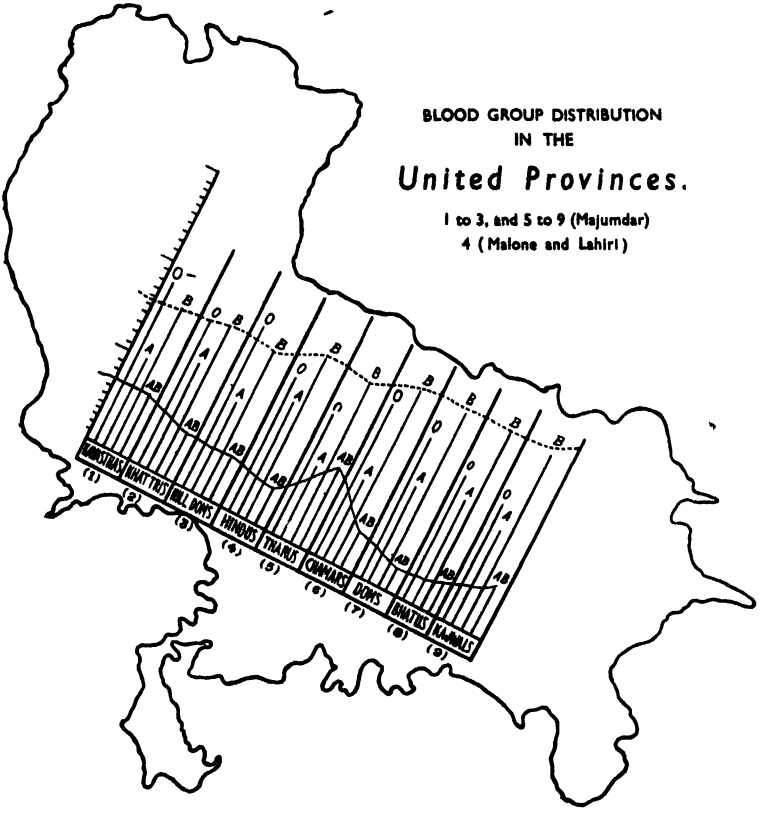
No.	*O*	*A*	*B*	*AB*	*B*+*AB*
Tharus (male and female)—(241) ..	27·1	17·0	37·5	18·4	55·9
Tharu females—(82) ..	25·6	13·4	42·7	18·3	61·0
Tibetans (Tennants)—187	14·9	47·1	13·9	24·1	38·0

Evidently the Tharus show a very high incidence of *AB* which I should think, is larger than that obtained for any Indian caste or tribe except the Tibetans who live on the north-east of India. Even the Tibetans do not show as high a percentage of (*B*+*AB*) as do the Tharus. Should we therefore conclude that this high *AB* (also *B*) among the Tharus may have given them an immunity to malaria? While measuring the Tharus, I found a number of them were suffering from fever. I noted their number in the register and discovered later that most of those belonged to group *A* while 78 p.c. of the (*B*+*AB*) group on enquiry said that they were not habitual victims of malarial infection. This, however, may be a mere coincidence but it may also indicate some correlation that exists between blood groups and malaria.

The high incidence of *B*+*AB* may mean that *O* and *A* are disappearing by the selective action of the environment, leaving *B*+*AB* to multiply. This is not surprising when we remember how the Negroes of the south (in America) who were used to a warmer climate when driven to the north have succumbed to pulmonary diseases and this is one big single cause of depopulation of the native population in America.

The Tharus derive themselves from a mixture of Rajputs and Nepalese; some say from Rajput women and their menials, the 'Chamars' and 'Saises' and the dominance of the women in the Tharu country is believed to be due to this. The Chamars do not possess mongolian cast of face and Rajputs do not have epicanthric folds in their eyes but most of the Tharus have. Besides, the Rajputs of Northern India have a high *A* value and less *B* and it is difficult to explain the very low incidence of *A* among the Tharus unless we suppose that the *B*+*AB* group has succeeded in acclimatizing themselves while *A* has not. The large incidence of *B*+*AB* may both be the cause and effect of a process of inbreeding, and if *B*+*AB* are immune from malaria, the Tharus as a group now is more immune than the other groups in the neighbourhood. This, however, needs to be

corroborated by blood group data from other malarial districts in different parts of India. Wiener reported the results obtained



by certain Russian investigators which indicate that individuals of Group *O* are less likely to contract malaria than those of group *AB* or group *B*. It must be mentioned here that the two groups *B*+*AB* are infrequently met in Russia and the percentage of *O* is greater than *B* and *AB*. But the Tharu data show a high *B*+*AB* value and also that persons with the *B*+*AB* group suffer less from malaria than *O* or *A*. I do not think that such divergent results are necessarily inconsistent, for the climatic conditions in one part may afford immunity to those of a particular group, while another set of climatic conditions may favour a different blood group in its struggle for adaptation. As a matter of fact all reported correlation between blood groups and diseases could not be corroborated by further investigations. I should think that hasty interpretation of results based on small

samples is perhaps responsible for this and I would plead for an extensive blood group investigations before we admit negative results. But once a people is known to have developed an immunity, the task of applied anthropology begins.

From a comparison of the blood group data available yet, it appears that the *B* concentration is most marked among those social groups which have passed from the tribal to caste status or those which are known to be hybrid castes. The depressed castes in Bengal show a high *B* concentration, so do the criminal tribes of Northern India. The Paniyanas (Aiyappan), the Naga tribes, Angami and Konyak, all exhibit lower percentage of *B*. But as soon as we include in our survey those tribes which are known to be mixed or those who from the nature of their occupation or otherwise allow inter-tribal marriages and extra-marital relationship with neighbouring tribes and castes, the percentage of *B* suddenly increases. Further data are required to substantiate the point, but all the same it appears that hybridization may have something to do with the increase of incidence of a particular blood group in the population.

If we arrange the serological values of (*A*-*B*) of all Indian tribes and groups available, we get the following arrangement:—

Caste or tribe.	(*A*-*B*)	Caste or tribe.	(*A*-*B*)
Hazaras ..	.. −14	Bengali Kayasthas	.. −11·7
Jats ..	.. −11	Bengali Brahmins	.. −12·0
Khatris ..	.. − 5	Bengali-Mahishyas	.. −19·4
Rajputs ..	.. − 5	All non-caste Hindus	−17·8
		Mohammedans	.. −16·7
		Santhals ..	.. −14·6
U.P. Hindus	.. −12·7	Marias ..	.. − 8·1
U.P. Kayasthas	.. −12·7	Chenchus	.. −19·0
U.P. Khatris	.. − 9·1	Goanese ..	.. − 6·5
U.P. Chamars	.. −20·6	Mahrattas	.. − 7·3
U.P. Doms	.. −16·6	Nairs ..	.. −13·1
U.P. Doms (Hills)	.. −13·8	Paniyans..	.. −52·8
U.P. Bhatus	.. −15·1	Syrian Christians	.. − 2·2
U.P. Karwals	.. −18·0	Tamils ..	.. − 5·4
U.P. Tharus	.. −20·5	Todas ..	.. −18·5
		Bhils ..	.. − 1·5
		Patelias ..	.. − 1·5

A classification of the tribes and castes into the following groups with values, (−5 and above), (−5 and −15) and (−15 and below) gives the following arrangement with respect to their *A*-*B* values:

(X−5)	(−5 and −15)	(−15 and below)
Paniyans, S. India ..	Tamils, S. India.	Non-caste Hindus, Bengal.
Chenchus ,, ..	Khattris, Punjab.	Mohammedans, Bengal.
Nairs ,, ..	Rajputs, C. India.	Mahishyas, Bengal.
Syrian Christian, S. India.	Hazaras, Punjab.	Doms, U.P.
Bhils, South India (Majumdar).	Jats, Punjab.	Bhatus, ,,
Patelias, S. India ..	Bengal Kayastha.	Karwals, ,,
		Haburas, ,,
	Bengal Brahmins.	Todas, Nilgiri.
	Goanese, Goa.	Tharus, U.P.
	Mahrattas, Bombay.	

It appears therefore that the highest negative values are obtained among the criminal tribes, the Tharus, the non-caste Hindus, Mohammadans and Mahishyas of Bengal. These castes and groups as we know, are of mixed origin. The Tharus are a mongoloid tribe with mixed non-mongoloid traits. They claim mixed descent from Rajputs and Nepalese. The Mohammedans of Bengal are a heterogeneous group because their ranks have swelled by conversion. The Mahishyas originally of aboriginal descent have been fortunate in assimilating non-aboriginal features, while the non-caste Hindus of Bengal are certainly not a homogeneous group. The Doms are a mixed group, so are the Karwals and Bhatus. Thus the high *B* percentage may have arisen from hybridization as we already suggested before.

That this is the experience of field workers will be evident from what Macfarlane observed on the basis of a large number of investigations. She noticed that in the few instances where there were data from two related communities in one locality (except in Cochin) the lower caste or that which probably contains more Dravidian admixture shows a high frequency for *B*. I should put the 'Dravidian' out of this statement as I think the term is a 'misnomer'. If this be true, it is necessary to collect data from groups living in the same locality. Until such data are available the mutation hypothesis should wait. Like many other anthropometric tests the biochemical evidence should be handled with caution till the data speak for themselves.

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The Tharus of Kheri Forests (U P.).











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ARTICLE NO. 4.

Respiratory Adaptations of the South Indian Homalopterid Fishes.

By SUNDER LAL HORA *and* NIRMAL CHANDRA LAW.

In a recent paper, one of us [1] dealt with the taxonomy of the Homalopterid fishes known from Peninsular India, and discussed the zoogeographical significance of their occurrence in this part of the country. He described representatives of three genera, *Balitora* Gray, *Bhavania* Hora and *Travancoria* Hora, belonging to the subfamily Homalopterinae. Of these, *Bhavania* is unique among the Homalopterinae in having the gill-openings restricted to above the bases of the pectoral fins. In the Gastromyzoninae, however, several genera, such as *Gastromyzon* Günther, *Pseudogastromyzon* Nichols, *Neogastromyzon* Popta, *Beaufortia* Hora and *Sewellia* Hora, possess similarly modified gill-openings. Besides the reduction of the gill-openings, the structures associated with the mouth, such as lips, barbels, rostral groove, etc., have also undergone structural adaptations in connection with the respiratory needs of the respective fishes. In a general way these modifications were discussed by Hora [2] in 1932. In this communication we give in greater detail the various modifications in structure connected with the respiratory activities of the South Indian forms.

The respiratory movements of *Balitora brucei* Gray were described by Hora [3] in 1923. It was observed that under normal circumstances only a small upper part of the gill-opening, provided with a broad gill-membrane, was functional, while the lower portion was rarely, if ever, used. It was also found that the fish was capable of suspending its respiratory movements for fairly long periods and that whenever any undesirable object entered the mouth it was spouted out with considerable force and thrown away at a distance of an inch or so. In the case of *Hemimyzon yaotanensis*, Fang [4] observed that the fish 'keeps its head up and down in continuously harmonic motions with the closing and opening of the branchial valves and the ceaseless vibrating of the posterior vertical portions of the pectorals while in respiration'. Hora (*loc. cit.*, 1923, p. 594) found that during respiration the snout of *B. brucei* was slightly raised above the

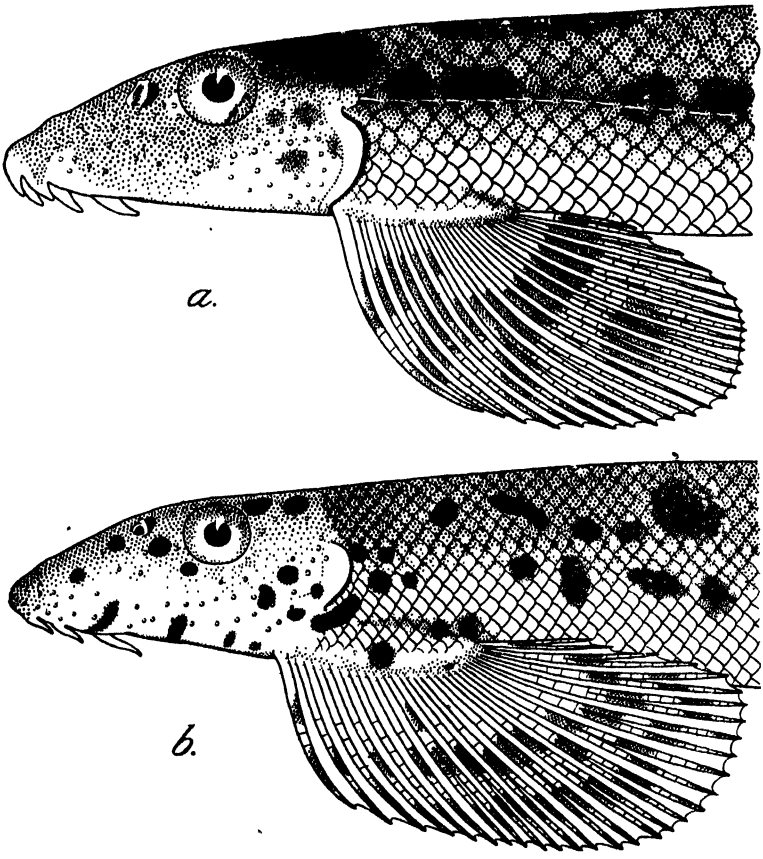
[1] Hora, S. L., *Rec. Ind. Mus.*, XLIII, pp. 221–232, pl. viii (1941). On pages 227 and 228, it is stated that the Sethumalai Hills are in Mysore. Mr. B. S. Bhimachar has kindly informed me that these hills form a part of the Anamalai Hills, which are situated to the south of the Nilgiri Hills.

[2] Hora, S. L., *Mem. Ind. Mus.*, XII, pp. 325–327 (1932).

[3] Hora, S. L., *Rec. Ind. Mus.*, XXV, p. 594 (1923).

[4] Fang, P. W., *Sinensia*, I, p. 142 (1931).

level of the substratum. He further remarked that 'It seems quite probable that the inner rays of the paired fins, which show



Text-fig. 1.—Lateral view of head and anterior part of body of *Travancoria* Hora and *Bhavania* Hora, to show the nature and extent of their respective gill-openings. ×3½.

a. Travancoria jonesi Hora; *b. Bhavania australis* (Jerdon).

peculiar movements, are used in driving away the excess of water that may enter below the fish from the anterior end. In still water these rays stop moving to and fro, thus showing that it is only in rapid water that their movements are useful to the fish. By continually pumping out the leakage water from underneath the fish they are directly helping the adhesive surface in the performance of its function. There is a regular channel at the base of pectoral fin along which the water moves before it is expelled at the posterior end and a current flowing in this groove

can be seen by placing a few drops of carmine solution near the anterior end of the base of the pectoral fin'. Thus the movements of the inner rays of the pectoral fins are not associated with respiration, but with adhesion by creating low pressure underneath the fish.[1]

At our request Mr. S. Jones conducted experiments on the respiratory movements of *Bhavania australis* in the Kallar Stream, about 30 miles north-east of Trivandrum, by using the same technique as employed in Hora's experiments on *Balitora brucei* (*loc. cit.*) and observed that

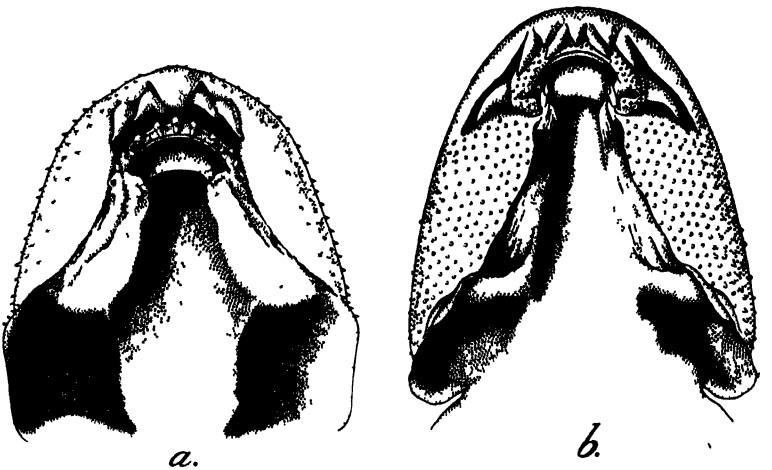
'Carmine powder placed under the anterior end of the fish is taken in and exhaled with the two tiny continuous streams which emerge from the small gill-openings. The respiratory movement is very fast, and its rate was not counted. When any large mass of foreign matter enters the mouth, it is spouted out with force. The movement of the posterior portions of the paired fins does not seem to have any relation to respiration for, when the fish is transferred to still water, this movement is stopped after a short time. Any slight disturbance in the water induces the resumption of the movement. In nature, whether the current is slow or fast, the posterior portions of the pectoral fins are always kept in motion. With the help of the paired fins, the fish gently crawls or glides forwards on the rocks. While breathing, the anterior lip is held just above the substratum, the four rostral barbels are directed towards the mouth, and the two maxillary barbels are directed outwards.

The fish does not suspend its respiratory movements either under water or outside of it. Though quite motionless otherwise, the fish, when lifted out of water by the tail, gasps for breath. When kept out of water, every drop of the liquid inside the gill-chambers is passed out first and afterwards air is taken in through the mouth and exhaled through the gill-openings. Fish taken out of water and held suspended by the tail is capable of living for 10–15 minutes, while if its mouth opening alone is under water the respiratory movements are not interrupted and the expiratory current continues to flow through the exposed gill-openings as two continuous streams. One of the fish was kept in this condition for 45 minutes and, though its surface dried up to some extent, it seemed to be quite healthy when returned to water.'

To comprehend fully the respiratory adaptations of the Homalopterid fishes, it is necessary to remember that these are greatly flattened forms in which the ventral surface and the paired fins, by which they adhere to rocks, are horizontal. The mouth is usually small and situated on the ventral surface considerably behind the tip of the snout. In swift currents there is a tendency among flattened organisms to obviate any flow of water underneath them, and this result has been accomplished in different ways. Among fishes, there are at least two genera, *Gyrinocheilus* Vaillant, a mountain carp known from Borneo and Siam, and *Arges* Cuv. & Val., a catfish of the Andes in South America, in which the mouth no longer serves as a passage for the inspiratory current. Here 'each gill-opening is divided into an upper slit-like portion, which serves as an inhalent opening and

[1] Hora, S. L., *Phil. Trans. Roy. Soc. London* (B), CCXVIII, p. 259 (1930).

communicates with the posterior part of the mouth cavity immediately in front of the gills, and a lower much wider portion which serves as an exhalent aperture and is guarded by a large membranous flap'[1]. In the Homalopterid and other hill-stream fishes investigated by Hora (*loc. cit.*, 1923, pp. 591–596), the gill-openings are divided into an upper and a lower part, but both are meant for the passage of the expiratory current—the upper part is functional while the lower rarely, if ever, comes into play. However, one definite purpose is served even by this simple modification and that is this; the water of the expiratory current is not discharged on the ventral surface of the animal. The object of intermittent respiration seems to be to keep the anterior end closely applied to the substratum during the periods when the respiratory movements are suspended. The lower part of the gill-opening being useless becomes closed up and we get the evolution of the genera like *Bhavania*, *Gastromyzon*, etc.



Text-fig. 2.—Dissections from the ventral surface of the buccal cavity and gill-chambers of *Balitora* Gray and *Travancoria* Hora. ×3½.

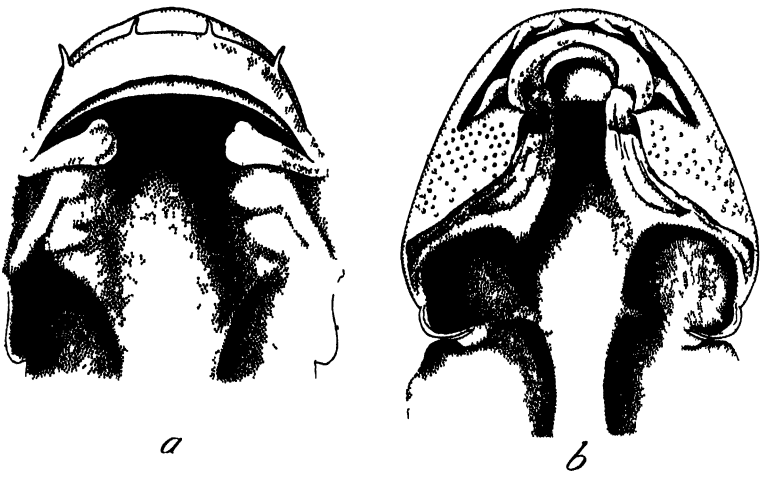
a. Balitora brucei Gray; *b. Travancoria jonesi* Hora.

The shaded parts represent the receptacles for the storage of water for respiration. Attention is also invited to the structure of the lips, rostral groove and rostral fold in the two forms.

With the reduction of the gill-openings and the small size of the mouth, it is obvious that the volume of the respiratory current is considerably reduced. One is led to the conclusion, therefore, that these fishes must possess some sort of receptacles

[1] Hora, S. L., *Journ. Bombay Nat. Hist. Soc.*, XXXVI, pp. 548–550 (1933)

for the storage of water, and on dissection it has been found that the pharynx and the gill-cavities have undergone certain modifications which enable them to store water. In *Balitora* and *Travancoria*, where the gill-openings are comparatively extensive, only shallow pouches are formed both along the roof of the mouth and in the gill-chambers, but in *Bhavania*, where the gill-openings are greatly reduced, the receptacles for water are well



Text-fig. 3 —Dissections from the ventral surface of the buccal cavity and gill-chambers of *Gastromyzon* Günther and *Bhavania* Hora.

a. Gastromyzon borneensis Gunther. ×3⅓, *b. Bhavania australis* (Jerdon). ×2⅔.

The shaded parts of the buccal cavity and gill-chambers represent the receptacles for the storage of water for respiration. Attention is also invited to the structure of the mouth parts of these fishes.

developed. So the reduction of the gill-openings and the development of the large pharyngeal and gill spaces for the storage of water seem to go hand in hand. In *Gastromyzon* the head is so depressed and flattened that separate storage pouches are not formed but the whole of the buccal cavity and the opercular chambers form one large continuous reservoir. In the evolution of storage cavities, these torrential fishes show a parallel development to the air-breathing fishes of India,[1] such as *Periophthalmus* Bloch and Schneider, *Periophthalmodon* Bleeker, *Taenioides* Lacépède, *Apocryptes* (Osbeck) Cuv. & Val., *Pseudapocryptes* Bleeker, *Boleophthalmus* Cuv. & Val., *Pisoodonophis* Kaup and a host of other estuarine fishes, in which the pharyngeal lining and the gill-chambers serve

[1] Hora, S. L., *Trans. Nat. Inst. Sci. India*, I, pp. 1–16 (1935); *Proc. Nat. Inst. Sci. India*, V, pp. 281–287 (1937).

as the main respiratory organs. After taking in a gulp of fresh air, the type of air-breathing fishes enumerated above suspend their respiratory movements for fairly long periods. In this connection reference may be made to Hora's contention that the present-day diverse structures associated with aerial respiration in fishes seem to have developed originally to increase the area for aquatic respiration and only 'under adverse conditions of stagnation and drought, took up the function of aerial respiration. The accessory respiratory organs, however, can be used for both aerial and aquatic respiration under suitable conditions' (Hora, *loc. cit.*, 1935, p. 14). The above view has recently been confirmed by Wu and Liu [1] in their elaborate experimental studies on *Monopterus javanensis* (*Fluta alba*); they have also found that the bucco-pharyngeal epithelium, though habitually employed as the organ of air-breathing, proves effective for aquatic respiration also. Conversely, it should also be possible to keep torrential fishes alive in air provided their bucco-pharyngeal epithelium can be kept moist. Mr. Jones's experiments on *Bhavania* reported above clearly show that under adverse conditions the pharyngeal and gill pouches of the highly specialized Homalopterid fishes can subserve aerial respiration for short period or probably as long as their gills remain moist.

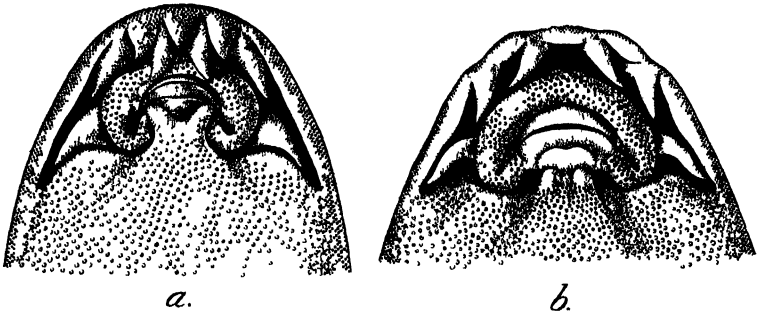
These results are of special value in elucidating the origin and function of the accessory respiratory organs in fishes.

It may here be noted that though normally all torrential fishes are water-breathers, during periods of drought when the streams are liable to break up into a series of pools and puddles, certain types,[2] such as *Amblyceps*, *Olyra*, *Lepidocephalus*, *Acanthophthalmus*, etc., with normal gill-openings, resort to aerial respiration. As pointed out by Hora,[3] under these conditions the epithelial lining of the buccal cavity and of the enlarged gill-chambers, though normally used for aquatic respiration, subserve aerial respiration.

We have already pointed out that in the Homalopterid fishes the respiratory current enters through the mouth and for this reason the anterior end is slightly raised to allow the passage of water to the mouth. In a majority of the forms, there is a rostral groove in front of the mouth which is continued round the corners of the mouth into labial grooves and the radiating side channels diverging from them posteriorly. These grooves are no doubt developed to regulate the flow of water along definite channels and to prevent its spreading under the whole surface. In the rostral and labial grooves and on the lips surrounding the mouth barbels or other tentacular processes are developed for

[1] Wu, H. W. and Liu, C. K., *Sinensia*, XI, pp. 231–238 (1940). Also see review of it by Hora, S. L., *Curr. Sci.*, X, pp. 379, 380 (1941).
[2] Hora, S. L., *Trans. Nat. Inst. Sci. India*, I, pp. 11, 12 (1935).
[3] Hora, S. L., *Rec. Ind. Mus.*, XXXV, pp. 612–616 (1933).

testing the purity of the water that is used for respiratory purposes. In *Balitora brucei* the lips are continuous and strongly fringed all over, while in *Bhavania* and *Travancoria* the lips are so adapted that the water can only pass into the mouth, when it is applied to the substratum, from the sides of the middle part of the lower lip where gaps exist between it and the lateral parts of the lip. The middle part of the lower lip is



Text-fig. 4.—Ventral surface of the anterior part of head in *Travancoria* Hora and *Bhavania* Hora to show the nature of the mouth and the structure of the associated parts. × *ca.* 5.

a. Travancoria jonesi Hora; *b. Bhavania australis* (Jerdon).

The central portion of the posterior lip in these two forms is modified into two papilla-like structures which guard the entrances of the inspiratory current to the mouth. In figure *a* they are shown as plugging the inspiratory channels, while in figure *b* they are shown pulled backwards to permit the inspiratory current to enter the mouth.

provided with two well-developed papillae, which when thrust forwards, are capable of closing up the gaps, and when pulled backwards leave passages for the flow of the water into the mouth. The papillae are sensory and are capable of testing the water as it flows through the passages. The rostral barbels, 4 in *Bhavania* and 7 or more in two rows in *Travancoria*, also serve for testing the respiratory current. The lips are thick and papillated and would help to seal the mouth when the respiratory movements are suspended. The modifications of the mouth and associated structure are very diverse in the Homalopteridae, and serve as valuable diagnostic characters for distinguishing genera and species.

Summary.

The respiratory movements of *Balitora*, *Hemimyzon* and *Bhavania* are discussed and correlated with the habitat and form of the fishes. It is shown that the movements of the inner rays of the pectoral fins are not associated with respiration. The probable causes which may have led to the reduction of gill-openings and the formation of receptacles for storage of water are explained. Attention is directed to the close parallelism

between the accessory respiratory chambers of the Homalopteridae and th bucco-pharyngeal chambers of certain air-breathing fishes of India. A account of the lips and associated structures of the Homalopteridae o South India is given and the probable functions of the various structure explained.

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ARTICLE No. 1.

On a Small Collection of Fish from Iraq.

By SUNDER LAL HORA *and* K. S. MISRA.

In October, 1941, a small collection of fifteen specimens, comprising thirteen species, was received from Mr. Dimitry D. Belayew, Specialist in Fisheries, Directorate General of Agriculture, Baghdad, Iraq, for determination. The material was accompanied by photographs of six species and a list containing the local (Arabic) names of the fishes, their classification into families and in the case of three species their probable specific names. The fishes were stated to have been collected from 'the Persian Gulf and from the Hors and the Rivers Shatt-al-Arab, Tigris and the Euphrates'. According to Mr. Belayew, at least fifty kinds of fish are found in these waters.

The material under report has proved of unusual interest, for most of the species represented in it are known from few specimens and, in consequence, their range of variation is not known. We have, therefore, amplified the earlier descriptions by noting the characters in which our specimens differ from the original accounts. One species, *Barbus* (*Puntius*) *luteus* (Heckel), has been redescribed, while two others, which seem to be new to science, are described in detail.

We wish to express here our great indebtedness to Mr. D. D. Belayew for affording us an opportunity to examine such interesting material and for his notes on and photographs of the fishes. The drawings were executed by Babu R. Bagchi, Artist, Zoological Survey of India, to whom our thanks are due.

The following thirteen species are represented in the collection:—

Order ISOSPONDYLI.
- Family CLUPEIDAE.
 1. *Hilsa ilisha* (Hamilton).

Order OPISTHOMI.
- Family MASTACEMBELIDAE.
 2. *Mastacembelus haleppensis* (Bloch & Schneider).

Order EVENTOGNATHI.
- Family CYPRINIDAE.
 3. *Barbus* (*Puntius*) *luteus* (Heckel).

Order NEMATOGNATHI.
- Family SILURIDAE.
 4. *Silurus triostegus* (Heckel).
- Family BAGRIDAE.
 5. *Mystus halepensis colvillii* (Günther).

Order PERCOMORPHI.
- Family MUGILIDAE.
 6. *Mugil* (*Liza*) *hishni* Misra, sp. nov.
 7. *Mugil* (*Liza*) *oligolepis* (Bleeker).

Family POLYNEMIDAE.
8. *Polydactylus* (*Eleutheronema*) *tetradactylus* (Shaw).
Family SPARIDAE.
9. *Acanthopagrus berda* (Forskål).
Family DENTICIDAE.
10. *Petrus belayewi* Misra, sp. nov.
Family OTOLITHIDAE.
11. *Otolithus ruber* (Bloch & Schneider).
Family SILLAGINIDAE.
12. *Sillago sihama* (Forskål).
Order CATAPHRACTI.
Family PLATYCEPHALIDAE.
13. *Platycephalus indicus* (Linnaeus).

Hilsa ilisha (Hamilton).

1917. *Hilsa ilisha*, Regan, *Ann. Mag. Nat. Hist.* (8), XIX, p. 306.
1940. *Hilsa ilisha*, Hora, *Journ. Roy. As. Soc. Bengal, Science*, VI, pp. 93-112, plates 5, 6, text-figs. 1-8.
1941. *Macrura ilisha*, Fowler, *Bull. U.S. Nat. Mus.* (100), XIII, p. 633.

Arabic Name: SBOUR.

Of the two specimens of *Hilsa ilisha* in the collection, the larger, about 388 mm. in total length, is without lateral spots, while the smaller, about 342 mm. in total length, has 6 to 7 spots. The spotted condition is usually characteristic of young and immature specimens, but we have found that even larger specimens caught higher up in the Ganges system near Allahabad are generally marked with a series of lateral spots. It is probable that the spotted condition of the individuals of this species is associated with life in fresh waters.

Hilsa ilisha is an anadromous fish and is known to ascend for considerable distances into all large rivers falling into the Persian Gulf and the seas of India and Burma.

Mastacembelus haleppensis (Bloch & Schneider).

1912. *Mastacembelus haleppensis*, Boulenger, *Journ. Acad. Nat. Sci. Philadelphia* (2), XV, pp. 198, 200.

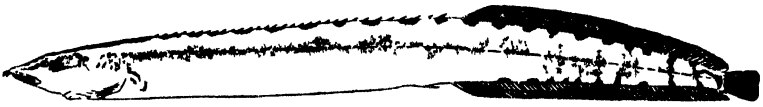
Arabic Name: SAEBOUH ABOU SIYAN.

There is a single specimen of *Mastacembelus*, 496 mm. in length, which we assign to *M. haleppensis*, although it differs in certain respects from the previous descriptions of the species. According to Boulenger's 'Synopsis of the Fishes of the Genus *Mastacembelus*', this species is characterized as follows:—

The snout is scaly only on the sides; the anal spines are close together; the caudal fin is embraced by the dorsal and anal fins but is separated from either or both by a notch; the anal opening is nearer to the base of the caudal fin than to the end of the snout; a preorbital spine is present but there are no preopercular spines (D. XXXII-XXXV 80-90; A. III 80-90); the

mouth extends to below the anterior border of the eye and the head is contained from 6½ to 7½ times in the total length.

In the specimen under report, the dorsal and the anal fins are somewhat shorter (D. XXXI 73; A. III 73); the middle



Text-fig. 1. Lateral view of *Mastacembelus haleppensis* (Bloch & Schneider): × 1/5.

anal spine is the longest and the third could only be made out after careful dissection. It may be remarked that Günther[1] also observed only thirty spines in the dorsal fin of a specimen from the Tigris river and it seems probable that the typical examples from the Euphrates may differ from those found in the Tigris in this respect. The preorbital spine is also very small and could only be made out with difficulty. The pectoral fins are stumpy and appear to be either deformed or diseased.

According to Günther, the colouration of the species is as follows:—

'Above blackish, variegated with dark yellow spots; yellowish below; anal fin yellow near its commencement, the rest, like the dorsal and caudal, being spotted with black.'

In the specimen under report, the general colour is grayish, somewhat darker above than below; along the dorsal surface of the head and the anterior part of the trunk for a distance equal to the length of the snout there is a broad dark, irregular streak beyond which the dorsal surface is provided with about twenty-one rounded or elliptical black spots which are closer together towards the posterior end. Along the lateral line, there is a broad longitudinal streak which becomes broken up into irregular spots after the middle of the body, and joining with the spots above forms vertical bands in the posterior part of the tail. The lower part of the body in the tail region is variegated with smaller spots, some of which form a series at the base of the anal fin. The dorsal, caudal and anal fins are irregularly marked with spots and short bands.

Measurements in millimetres.

Total length	495·0
Standard length	470·0
Length of head	76·0
Depth of body	42·5
Diameter of eye	7·0
Length of snout to base of proboscis	19·0
Interorbital distance	5·5

[1] Günther, A., *Ann. Mag. Nat. Hist.* (4), XIV, p. 36 (1874).

Barbus (Puntius) luteus (Heckel).

1841. *Systomus luteus*, Heckel, in Russegger's *Reisen in Europa, Asien und Africa*, I, p. 1016, pl. 6, fig. 1.
1868. *Barbus luteus*, Günther, *Cat. Fish. Brit. Mus.*, VII, p. 141.

Arabic Name: BINNI HIMRI.

There is a single specimen of a Cyprinoid fish in the collection which we assign to *Barbus luteus*. According to Günther,[1] it occurs 'in the Orontes, throughout Mesopotamia and Persia'. In recording this species from the Tigris, Günther (*loc. cit.*) placed it in his genus *Barynotus* and observed:—

'Since I have had the opportunity of examining specimens collected by the Marquis Doria at Shiraz, I have convinced myself that it should be removed from the genus *Barbus* (or *Systomus*), to which Heckel had referred it, and placed in *Barynotus*.'

On referring to later literature, it appears that Weber and de Beaufort [2] have confined the genus *Barynotus* to *B. microlepis* (Bleeker) known from Sumatra and Borneo. In regard to Günther's logotype [3], *B. layensis* Günther, they observe that

'According to our opinion *Barynotus lagensis* Gthr. does not belong to this genus, but belongs to *Barbus s. lat.*, where this species has been placed by Boulenger (Cat. Freshwater fishes Africa II. 1911, p. 100). Thus *Barynotus* only contains the one species from the Indo-Australian Archipelago.'

It seems that Günther (1868, p. 62) was also aware of certain fundamental differences between the two species he had originally assigned to the genus *Barynotus*, for under the description of *B. microlepis* he observed:—

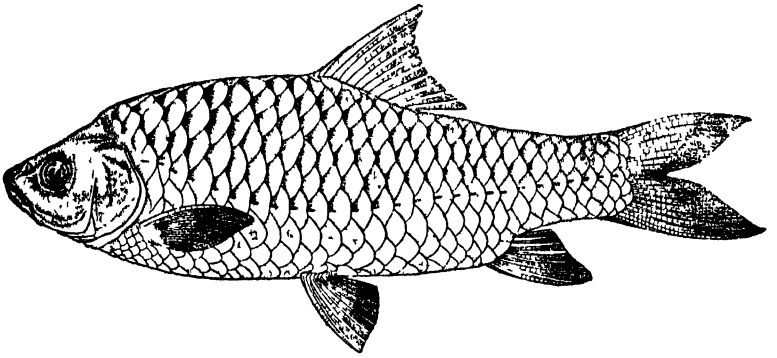
'Although this species differs in a number of well-marked characters from the other, I hesitate to separate them generically, as we have seen a continuous chain of species distinguished by the very same characters in the genus *Barbus*.'

Without going further into the validity of the genus *Barynotus*, as restricted by Weber and de Beaufort, we feel certain that the species from the Tigris under report is generically not very different from the large number of Indian species grouped under *Puntius* Hamilton. As we have not found any suitable description of *B. luteus*, we describe fully the specimen from the Tigris river examined by us.

In *Barbus luteus* the dorsal surface is more arched than the ventral and the dorsal profile rises abruptly from the tip of the snout to the base of the dorsal fin. The ventral profile is more

[1] Günther, A., *Ann. Mag. Nat. Hist.* (4), XIV, p. 37 (1874).
[2] Weber, M. and de Beaufort, L.F., *Fish. Indo-Austral. Archipel.* II, pp. 119, 120 (1916).
[3] Jordan, D. S., *The Genera of Fishes*, p. 351 (Stanford University, California, 1919).

regularly arched. The head is relatively small and pointed anteriorly; its length is contained 5·5 times in the total length



Text-fig. 2. Lateral view of *Barbus* (*puntius*) *luteus* (Heckel): × *ca* 2/5.

and 4·3 times in the length without the caudal. The eyes are situated almost in the anterior half of the head; the diameter of the eye is contained 4 times in the length of the head, 1·24 times in the length of the snout and 1·84 times in the interorbital distance. The mouth is subinferior and bordered by moderately developed lips; the labial groove is widely interrupted in the middle. The rostral fold partly covers the upper lip and is provided with short lateral grooves. There is a pair of short maxillary barbels arising from the grooves round the corners of the mouth.

The depth of the body is considerably greater than the length of the head and is contained 3·8 times in the total length and 3·05 times in the length without the caudal. The tail portion behind the anal fin becomes narrow abruptly; the least height of the caudal peduncle is contained 1·22 times in its length. The body is covered with relatively large and well-developed scales; there are twenty-eight scales along the lateral line, 2½ rows between the lateral line and the base of the pelvic fin and ten in front of the dorsal fin. The number of scales round the caudal peduncle is fourteen. There is an adnate scaly appendage in the axil of the pelvic fin.

The dorsal fin commences opposite the pelvics and its commencement is almost midway between the tip of the snout and the base of the caudal fin. The dorsal spine is strong and bony, except near the tip where it is flexible; it is almost as long as the head behind the nostrils. The longest ray of the pectoral fin is equal to that of the dorsal spine; the pectoral fin is separated from the pelvic by a considerable distance. The pelvic fins are considerably shorter and are approximated ventrally. The longest ray of the anal fin is shorter than that of the

dorsal. The caudal fin is deeply emarginate with both the lobes pointed, the lower lobe being slightly longer than the upper.

The colour in the preserved specimen has faded considerably The dorsal surface and sides almost up to the lateral line are grayish while the lower surface is much lighter. In the upper half, there are dark markings at the bases of the scales. The fins, specially in their distal parts, are light gray.

Measurements in millimetres.

Total length	273·5
Standard length	220·0
Length of head	51·0
Height of head at occiput	39·0
Width of head	37·0
Diameter of eye	12·5
Length of snout	15·5
Interorbital width	23·0
Depth of body	72·0
Width of body	39·5
Length of caudal peduncle	36·0
Least height of caudal peduncle	29·3
Height of dorsal fin	43·0
Length of dorsal spine	42·0
Longest ray of pectoral fin	42·0
Longest ray of pelvic fin	35·0
Longest ray of anal fin	39·0
Length of maxillary barbel	4·5

Silurus triostegus (Heckel).

1841. *Silurus triostegus*, Heckel, in Russegger's *Reisen in Europa, Asien und Africa* etc., I, p. 1090, pl. 13, fig. 1.
1864. *Silurus triostegus*, Günther, *Cat. Fish. Brit. Mus.*, V, p. 429.

Arabic Name: DJIRRI.

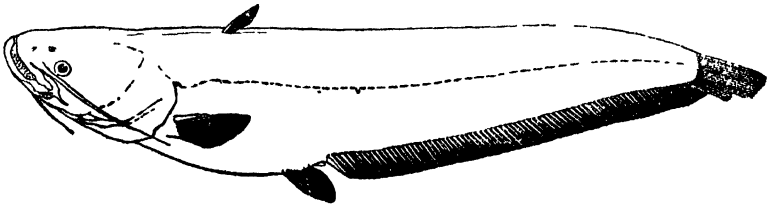
D. 4; A. 80; P. 1/14; V. 13; C. 18.

There is only one specimen, 294 mm. in total length, which we assign to *Silurus triostegus* (Heckel). In comparing our specimen with Günther's brief description of the species, we find that its head is relatively longer, being contained 4·59 times in the total length *versus* 'five times and one-fourth' and the pectoral spine is smooth along both the inner and outer edges *versus* 'Pectoral spine serrated'. The two agree as regards the prominent nature of the lower jaw, the respective lengths of the barbels, and the union of the anal and caudal fins. It appears from Berg's recent work[1] that in recognizing species of this genus, he attaches little importance to the nature of the pectoral spine, for he has included Regan's[2] *S. bedfordi*, with the outer edge

[1] Berg, L. S., *Poiss, des. eaux douces de l' U.S.S.R.*, 3rd. ed., p. 587 (Leningrad), 1933.
[2] Regan, C. T., *Proc. Zool. Soc. London*, p. 61 (1908).

of the pectoral spine roughened or finely serrated and inner edge entire, under the synonymy of his *Parasilurus asotus*, in which both edges of the pectral spines are serrated. The length of the head also is a variable character, especially when young and half-grown specimens are compared with fully grown individuals. It would thus appear that, in spite of the differences noted above, our specimen may belong to *S. triostegus*, a species described by Heckel from the Tigris river which is also the locality of the specimen studied by us.

S. triostegus is thus distinguished from *S. asotus*, of which *S. chantrei* (Sauvage) [1] from Tiflis with smooth pectoral spines and long barbels is probably a synonym, by its short barbels which do not extend beyond the head, but as shown by one of us [2] in the case of the Indian species of *Silurus* and allied genera, much reliance cannot be placed on the extent of the maxillary and mandibular barbels in different individuals for specific differentiation. It was also pointed out that the presence or



Text-fig. 3. Slightly dorso-lateral view of *Silurus triostegus* (Heckel): × *ca* 3/8.

absence of an additional pair of mandibular barbels is not sufficient for separating species generally, and for this reason *Parasilurus* was not recognized as a distinct genus. Recent findings of Bhimachar and Rau [3] have lent support to this view. There would thus appear to be *a priori* grounds for regarding *S. triostegus* also as a mere variant of the widely distributed palaearctic species *S. asotus*, but we have not sufficient material at our disposal to decide this taxonomic point. Günther [4] in describing the fishes of the Lake Urmir made the following remark regarding *S. triostegus* under the account of *S. glanis*:—

'I have some doubts as to whether *S. triostegus* of Heckel, from the Tigris, can be maintained as a distinct species. The dorsal fin of *Silurus* is a rudimentary organ, and therefore may be expected to vary in the number and development of its rays.

[1] Sauvage, M. H. E., *Nouv. Archiv. Mus. Hist. Nat. Paris* (2), VII, p. 19, pl. I, fig. 1. (1884).

[2] Hora, S. L., *Rec. Ind. Mus.*, XXXVIII, pp. 351-361 (1936).

[3] Bhimachar, B. S. and Rau, A. Subba, *Journ. Mysore Univ.* (B), I, pp. 147-150 (1941).

[4] Günther, G. A., *Journ. Linn. Soc. London, Zoology*, XXVII, p. 383 (1899).

Even in European specimens the fourth dorsal ray is not constantly branched, but may be simple and reduced in size and I have found it so also in a specimen from the Tigris. However the barbels of Mesopotamian specimens seem to be shorter than in European.'

To facilitate reference in future we give below the measurements of the specimen examined by us. It may also be noted that the number of gill-rakers on the outer arch in the example from the Tigris is 14+3, while in some of the specimens of *S. asotus* examined by us the number on the lower part does not exceed 10.

Measurements in millimetres.

Total length	294·0
Standard length	266·0
Length of head	64·0
Width of head	46·0
Width of body	41·5
Depth of body	53·0
Diameter of eye	7·0
Length of snout	17·5
Interorbital width	25·0
Longest ray of pectoral	30·0
Length of pectoral spine	20·0
Length of maxillary barbel	58·5
Length of mandibular barbel	22·0

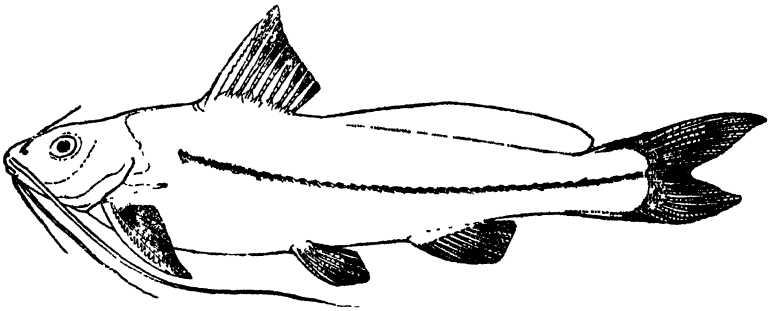
Mystus halepensis colvillii (Günther).

1794. *Silurus pelusius*, Russell, *Nat. Hist. Aleppo*, II, p. 210, pl. 7, fig. 1.
1841. *Bagrus halepensis*, Heckel, in Russegger's *Reisen in Europa, Asien und Africa*, I, p. 1091, pl. 8, fig. 2.
1865. *Macrones aleppensis*, Gunther, *Cat. Fish. Brit. Mus.*, V, pp. 75, 431.
1874. *Macrones Colvillii*, Gunther, *Ann. Mag. Nat. Hist.* (4), XIV, p. 36, pl. 8.

Arabic Name: ABOUZ-ZOUMEIR.

In 1874, Günther described and figured *Macrones colvillii* from Bagdad on the River Tigris and stated that its vernacular name is 'Abu Zumare'. We have examined a specimen from the same locality received under more or less the same vernacular name, but find that it differs from Günther's descriptions in two respects. It has a somewhat deeper body, the depth of the body being contained 4·81 times in the standard length *versus* 'six and a half times in the total length (without caudal)', and the adipose fin is about three times as long as the dorsal, and commences almost immediately behind the rayed dorsal fin *versus* 'The adipose fin is about twice as long as the dorsal, and *commences at a distance from it which is about equal to the length of the dorsal*'. By italicizing the portion of the description as indicated above, Günther seems to have attached great significance to the point of commencement of the adipose fin in distinguishing

his *M. colvillii* from allied species. In the points noted above, our specimen agrees with *Mystus halepensis* (Heckel), usually known under the name *Macrones aleppensis* (Heckel), but differs from Günther's description of the species in the nature and extent of the dorsal and pectoral spines, which are stated to be as long



Text-fig. 4. Lateral view of *Mystus halepensis colvillii* (Günther): × *ca* 3/4.

as the head without snout, 'dorsal spine of moderate strength scarcely serrated behind'. It would thus appear that the specimen examined by us is intermediate between the two species and that the points of differences noted above may be within the range of normal variations when large series of specimens are examined. For the present we regard *colvillii* as a variety of *halepensis*. It may be noted that Günther was aware of the close relationship of the two species, for in describing *M. colvillii* he remarked, 'much more slender than *M. aleppensis*, to which it is closely allied'. The slender form and the relatively shorter adipose fin of *M. colvillii* may be due to the fact that specimen was probably ill-nourished for some reason.[1] We give below the measurements of the specimen examined by us.

Measurements in millimetres.

Total length	150·0
Standard length	125·0
Length of head	28·0
Width of head	21·2
Depth of body	26·0
Diameter of eye	6·0
Length of snout	11·5
Interorbital width	7·5
Length of dorsal spine	20·0
Length of pectoral spine	20·3
Length of base of dorsal fin	18·0
Length of base of adipose fin	58·0
Length of nasal barbel	14·0
Distance between commencement of *V.* & *A.*	74·0
Length of maxillary barbel.	24·0
Longest ray of pelvic fin	14·5

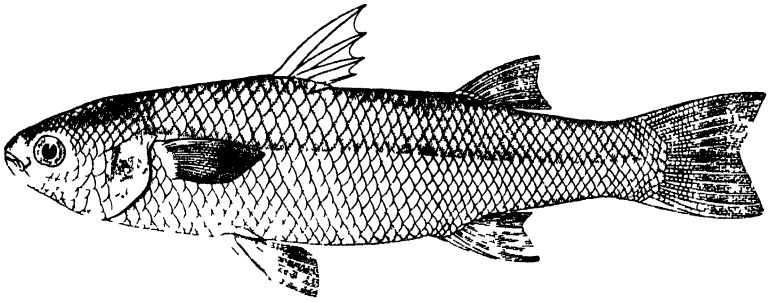
[1] Hora, S. L. and Misra, K. S., *Journ. Bombay Nat. Hist. Soc.*, XL, p. 35 (1938).

Mugil (Liza) hishni Misra, sp. nov.

Arabic Name: HISHNI or HASHSOUN.

D. 1. IV; D. 2. 1/8; A. III 8-9; P. 1/16; V. 1/5; C. 14; L. l. 46-49; L. tr. 15-16.

In this species of Mullet, the ventral profile is somewhat more arched than the dorsal. The length of the head is contained from 4·3 to 4·4 times in the standard length and from 5·2 to 5·4 times in the total length. The body is considerably deeper than the length of the head; its depth is contained from 3·7 to 4·1 times in the standard length and from 4·6 to 4·8 times in the total length. The diameter of the eye is contained from 3·1 to



Text-fig. 5. Lateral view of *Mugil* (*Liza*) *hishni* Misra, sp. nov.: × 2/5.

4 times in the length of the head, from 0·8 to 1·0 times in the length of the snout and from 1·3 to 1·5 times in the interorbital distance. The adipose eyelids are absent. The interorbital space is nearly flat. The anterior nostril is situated midway between the tip of the snout and the anterior margin of the eye. The lower margin of the preorbital bone is curved downwards and is denticulated. The maxillaries are exposed. The symphysial knob is single. The upper lip is fairly thick and is provided with small cilia. The gill-rakers are thirty-four+fifty; they are finely lanceolate, the longest being 2·3 in gill-filaments which are contained about 5·2 times in the length of the head.

The first dorsal fin is inserted about the 10th to 11th scale of the lateral line and is considerably nearer to the tip of the snout than to the base of the caudal fin; its first spine is very strong and is somewhat longer than the head. The length of base of the first dorsal is contained 2·8 to 2·9 times in the length of the head. There are about twenty-three or twenty-four predorsal scales. The second dorsal commences above the twenty-seventh to twenty-eighth scales of the lateral line; the second soft ray is contained from 1·6 to 2·0 times and

the length of its base from 2·7 to 2·9 times in the length of the head. The anal fin commences below the twenty-fourth to twenty-fifth scale. The pectoral fin extends as far as the eleventh or twelfth scale and its length is contained 1·3 times in the length of the head. There is no axillary scale. The pelvic fin is as long as the pectoral. The caudal fin is slightly emarginate with both the lobes pointed and equal. The least height of the caudal peduncle is contained from 1·7 to 2·1 times in its length.

The dorsal surface of the head and body and the sides above the lateral line are grayish and the lower surface is silvery. The second dorsal and the caudal fins are dusky. The margins of the scales are covered with small black dots.

Locality: Rivers and Hors, Iraq.

Type-specimen: F13626/1, Zoological Survey of India.

Remarks: *Mugil hishni* is closely related to *M. auratus* Risso[1] but the two can be distinguished by the following table of characters:—

Mugil hishni	*Mugil auratus*
1. Dorsal spine very strong; 1·1 to 1·2 in head.	1. Dorsal spine moderately strong; 1·6 to 2·0 in head.
2. Predorsal scales 24 to 25.	2. Predorsal scales 34 to 40.
3. Spinous dorsal much nearer tip of snout than base of caudal, both in adult and young specimens.	3. Spinous dorsal slightly nearer tip of snout than base of caudal; midway in young specimens.

Measurements in millimetres and scale counts.

Total length	260·0	127·0
Standard length	219·5	104·0
Length of head	50·0	23·5
Width of head	31·0	15·5
Diameter of eye	12·5	6·0
Length of snout	12·5	6·0
Interorbital distance	19·0	10·0
Depth of body	53·5	27·5
Length of first spine of 1st dorsal	40·0	21·5
Length of second spine of 1st dorsal	30·0	17·0
Length of third spine of 1st dorsal	26·0	12·5
Length of fourth spine of 1st dorsal	14·0	7·0
Length of second ray of 2nd dorsal	24·0	15·0
Length of base of first dorsal	17·5	8·0
Length of base of second dorsal	18·5	8·0
Length of pectoral fin	38·0	18·0
Length of pelvic fin	38·0	18·5
Length of second ray of anal fin	30·0	18·0
Distance between snout and commencement of 1st dorsal	98·0	46·0
Length of caudal peduncle	55·0	23·0
Least height of caudal peduncle	26·0	13·0
Predorsal scales	23	24
Scales along lateral line	46	49

[1] Fowler, H. W., *Bull. Amer. Mus. Nat. Hist.*, LXX, p. 589 (1936).

Mugil (Liza) oligolepis (Bleeker).

1935. *Mugil oligolepis*, Smith, *Ann. South Afr. Mus.*, XXX, p. 635, pl. 21, fig. B. and pl. 22, figs. C. & D.

Arabic Name: BIAHA.

In referring a specimen, 239 mm. in total length to *Mugil oligolepis* we have relied on Smith's (*loc. cit.*, pp. 598, 599) key to the Mugilidae of South Africa. Though Barnard[1] regarded *M. oligolepis* as more or less identical with *M. waigiensis*, Smith has shown that the two species with large scales, about twenty-six to twenty-eight along the lateral line, can be separated by the following characters:—

(*a*) 'Anal rays eight. Caudal almost truncate. Pectoral partly or wholly black .. *waigiensis.*

(*b*) Anal rays nine. Caudal emarginate. Pectorals light *oligolepis.*'

In the specimen examined by us and in the photograph of a much larger specimen sent by Mr. Dimitry D. Belayew, we find that the caudal fin is distinctly emarginate, the number of branched anal rays is nine and the pectoral fins are of pale colour. The tip of the second dorsal and that of the middle, shorter rays of the caudal are tinged with black. There is also a weak axillary spot and the body is marked with several faint longitudinal rows along the scales. As already noted by Smith, the spines of the first dorsal fin are stronger than is usually the case with most of the species of *Mugil*.

According to Smith, *M. oligolepis* has hitherto been described from juvenile specimens but he had a specimen 206 mm. in length.

The species has hitherto been recorded from Seychelles (Regan); South Africa (Delagoa Bay, Fowler; Isipingo Lagoon, Smith); seas and estuaries of India (Day); Saigon, Philippines, Malacca, North Celebes, and South and West Borneo. It is recorded here from the Persian Gulf for the first time.

Petrus belayewi Misra, sp. nov.

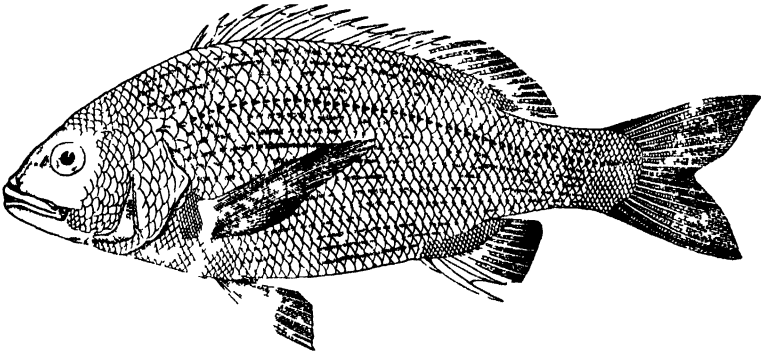
Arabic Name: TCHENDAL.

D. XII/11; A. III 8½; P. 1/14; V. 1/5; C. 17; L. l. 46+6; L. tr. 5½/13½.

In the new species of *Petrus*, both the dorsal and the ventral profiles are gracefully arched; the dorsal being somewhat more convex than the ventral. The length of the head is contained

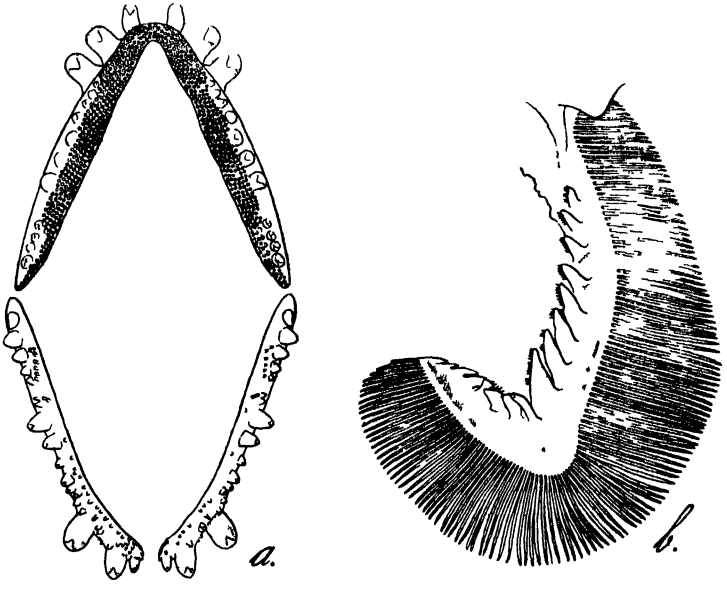
[1] Barnard, K. H., *Ann. South Afr. Mus.*, XXI, p. 1023 (1927).

3·4 times and the depth of the body 2 4 times in the standard length and 4·3 times and 3·0 times respectively in the total



Text fig 6 Lateral view of *Petrus belayewi* Misra, sp. nov.: × 2/5.

length The diameter of the eye is contained 3 8 times in the length of the head, 1·16 times in the length of the snout and 1·0



Text-fig. 7. *Petrus belayewi* Misra, sp. nov. *a* Dentition: × 2⅔; *b* An anterior gill-arch: × 2

times in the interorbital distance The mouth is large and the maxilla extends as far as the middle of the eye The jaws are

subequal. There are six canines in the upper jaw, the two inner being somewhat smaller, and four in the lower jaw. There are narrow bands of fine teeth in both the jaws, some of them near the posterior end of each jaw are molariform. The outer, lateral teeth are conical. The gill-rakers are short and laminate; there are nine of these on the lower limb of the anterior arch.

The dorsal fin commences above the opercular margin. The spines are rather short, the longest being less than half the length of head. The soft rays are somewhat longer. The length of base of the soft portion of the dorsal is almost half of that of the spinous portion. The anal commences below the second soft dorsal ray; the second spine is the longest and quite strong. The pectoral is much longer than the head and extends as far as the anal opening. The pelvic is considerably shorter than the head and does not reach the vent. The caudal fin is forked; both the lobes are pointed and the upper is slightly longer.

There are six rows of scales on the cheek. The interorbital space is also partly covered with scales.

The colour is olivaceous above and lighter below. The scales are provided with dark margins and the body is traversed with narrow, dark stripes. The inter-spinous membranes of the dorsal and anal fins are black. The anal fin and the lobes of the caudal fin are tinged with black. The other fins are of a much lighter colour.

Locality: Rivers and Hors, Iraq.

Type-specimen: F13628/1, Zoological Survey of India.

Remarks: *Petrus belayewi* differs from *P. rupestris* (Val.)[1] in the following particulars:—

	Petrus belayewi.	*Petrus rupestris.*
1.	L. l. 52; L. tr. 5½/13½.	L. l. 57-63; L. tr. 11-12/19-20.
2.	Six series of scales on cheeks.	17-18 series of scales on cheeks.
3.	Second anal spine longest.	Third anal spine longest.

I have great pleasure in associating the name of this species with that of Mr. Dimitry D. Belayew, through whose kindness we had the opportunity to examine this interesting material.

Measurements in millimetres.

Total length	253·0
Standard length	201·0
Length of head	58·0
Diameter of eye	15·0
Length of snout	17·5
Interorbital width	15·5
Depth of body	83·5
Length of 1st dorsal spine	10·0

[1] Smith, J.L.B., *Trans. Roy. Soc. S. Afr.*, XXVI, pp. 303, 304 (1938).

Length of 2nd dorsal spine	16·0
Length of 3rd dorsal spine	22·0
Length of 4th dorsal spine	27·0
Length of longest ray of soft dorsal	22·0
Length of 2nd anal spine	27·0
Length of 3rd anal spine	23·0
Length of pectral fin	62·0
Length of pelvic fin	43·0
Length of base of spinous dorsal	69·0
Length of base of soft dorsal	37·0

Otolithus ruber (Bloch & Schneider).

1936. *Otolithus ruber*, Weber & de Beaufort, *Fish. Indo-Austral. Archipel.*, VII, p. 490.

Arabic Name: NOUVEBI.

Otolithus ruber is represented in the collection by a single specimen. The species is known from the Coast of Natal, Delagoa Bay, seas of India and the Malay Peninsula.

Sillago sihama (Forskål).

1876. *Sillago sihama*, Day, *Fish. India*, p. 265, pl. 57, fig. 3.

Arabic Name: HASSOUN.

There is a single specimen, about 240 mm. in total length, of *Sillago sihama* in the collection. The species is said to attain a foot in length and is distributed from the Red Sea through the seas of India to the Malay Archipelago and beyond. It is known to ascend tidal waters.

Platycephalus indicus (Linnaeus).

1876. *Platycephalus insidiator*, Day, *Fish. India*, p. 276.
1936. *Platycephalus indicus*, Herre, *Rec. Ind. Mus.*, XLI, p. 340.

Arabic Name: WAHAR.

Platycephalus indicus is represented in the collection by a single specimen, 237 mm. in total length. Mr. Belayew also sent photographs of two other specimens.

The species is said to attain a size of at least a foot and a half. It is widely distributed in the seas of India and adjacent countries and ascends into fresh waters[1] also; its range extends from the Red Sea and the East Coast of Africa through the seas of India to the Malay Archipelago and beyond.

[1] Hora, S. L. and Nair, K. K., *Rec. Ind. Mus.*, XLII, p. 559 (1940).

Paper received—21-6-1943.
Paper published—18-11-1943.

Journal of the Royal Asiatic Society of Bengal. Science.
Volume IX, 1943.
ARTICLE No. 2.

Note on the colour of the iris, of the bare orbital skin around the eyes and of the edges of the eye-lids in the Indian Ring-Dove.

By M. L. ROONWAL.

(*Communicated by Dr. Baini Prashad.*)

In 1940 [1] I summarized the available data on the characteristics of the three subspecies of *Streptopelia decaocto*, namely, *S. d. decaocto* (Frivaldszky) (the Indian Ring-Dove), *S. d. stoliczkae* (Hume) (the Kashgar Ring-Dove), and *S. d. xanthocyclus* (Newman) (the Burmese Ring-Dove).

During a collecting tour in Rajputana in October-November 1941, Dr. B. N. Chopra and myself collected a few Ring-Doves which made it possible for me to observe the colour of the iris, of the bare orbital skin around the eyes and of the edges of the eye-lids in fresh specimens. The following observations were made on a fresh male of *S. d. decaocto* shot near R. Berach at Chittorgarh (Mewar State, Rajputana) on October 8, 1941.

Iris.—The iris was crimson-pink with a very thin outer black ring, the black ring not having been previously described in any of the subspecies.

Naked orbital skin around the eyes.—The colour of the naked orbital skin was *pale grey tinged, in irregular patches, with a distinct bright lemon-yellow.* Hitherto, the yellow tinge has not been recorded in *S. d. decaocto*, but has been considered as characteristic of *S. d. xanthocyclus.*

Edges of the eye-lids.—These were yellowish-white; hitherto only red edges have been recorded.

[1] Roonwal, M. L., *Rec. Ind. Mus.*, XLII, pp. 437–452 (1940).

Paper received—21-6-1943.
Paper published—19-11-1943.

Journal of the Royal Asiatic Society of Bengal. Letters.
Volume IX, 1943.
ARTICLE No. 3.

Notes sur quelques Cystocercoïdes de Crustacés de l'Inde.

par KNUT LINDBERG.

(*Communicated by Dr. Baini Prashad.*)

En examinant des Cyclopides récoltés à Nagaur et à Didvana dans l'Etat de Djodhpour (Radjpoutana) pour la recherche d'embryons du ver de Médine, un certain nombre d'entre eux ont été trouvés parasités par des Cystocercoïdes. Subséquemment des cyclopes pêchés à Ahmédabad (Goudjerate) ont montré une infestation semblable.

Pour autant qu'il me soit connu, une étude des Crustacés de l'Inde en tant qu'hôtes intermédiaires de Cestodes n'a jamais été faite, et nos connaissances sur les Cystocercoïdes mêmes, aussi bien en Europe qu'ailleurs, semblent encore très incomplètes.

On sait que ce sont des oiseaux qui servent d'hôtes définitifs aux formes larvaires observées chez les Crustacés. Il est à présumer qu'il reste toujours des Cestodes nouveaux à découvrir chez les oiseaux de l'Inde, et, autant que je sache, aucun Cystocercoïde de Crustacé n'a encore été décrit dans ce pays.

Dans un *Diaptomus* unique j'ai trouvé un *Cercocystis*, 'cystique' à long appendice caudal, selon la classification de Villot, qui manifestement doit être celui de *Hymenolepis gracilis* (Zeder), parasite d'oiseaux aquatiques (canards, etc.) bien connu, dont le ver adulte a été retrouvé dans l'Inde.

D'assez nombreux *Thermocyclops hyalinus* (Rehberg) se sont montrés infestés par une deuxième forme, dont le ténia adulte semble devoir être *Hymenolepis rugosa* Clerc, espèce décrite des monts Ourals en Russie et ensuite signalée chez des pigeons à Rangoon (Birmanie).

Des Cystocercoïdes de dimensions plus petites et dont les crochets montraient une structure un peu différente de celle de l'espèce qui vient d'être mentionnée, parasitaient la grande majorité des *Thermocyclops vermifer* Lindberg, pêchés dans un réservoir à Ahmédabad, ce Cyclopide se rapprochant d'ailleurs beaucoup de *Th. hyalinus*.

Il ne m'a pas été possible d'identifier le quatrième Cystocercoïde, car je n'y ai pas pu distinguer les crochets, s'il en existe, ce qui ne semble pas être le cas. Je l'ai figuré et décrit tel qu'il m'a apparu, et ces notes sont données dans l'espoir qu'elles susciteront des travaux plus circonstanciés sur les Cystocercoïdes des Crustacés de l'Inde.

Pour montrer le taux d'infestation par les parasites dans les habitats où j'en ai trouvé, je donne une liste des animaux identifiés. J'en ai examiné de plus nombreux pour le travail

présent que je n'ai fait au cours des recherches sur la draconculose à Nagaur et à Didvana. Un tableau des Cyclopides actuellement connus comme hôtes intermédiaires de Cestodes a été donné à la fin Il se peut cependant qu'il soit incomplet

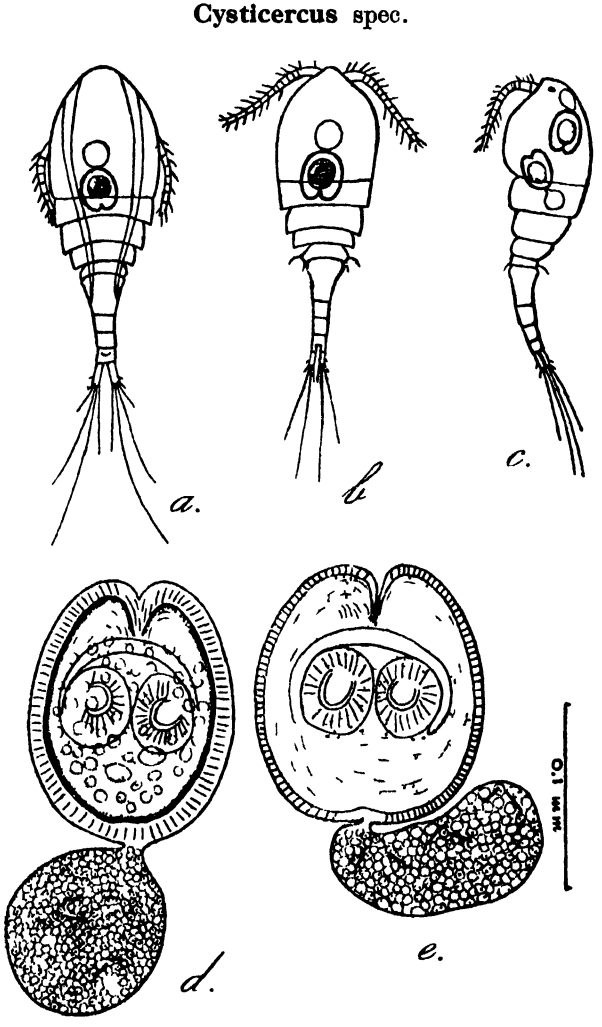


FIG 1 *Cysticercus* sp sans crochets.

a, *Mesocyclops leuckarti* à Cystocercoïde in situ, *b*, *Microcyclops varicans* à Cystocercoïde in situ; *c*, *Microcyclops varicans* montrant deux Cystocercoïdes; *d*, *Cysticercoïde* dégagé; *e*, Autre spécimen.

Longueur du kyste: 118 μ à 165 μ; moyenne 142 μ (32 mesurés).
Largeur du kyste: 83 μ à 125 μ; moyenne 107 μ (32 mesurés).
Configuration du kyste: arrondie, ovoïde.
Queue: arrondie, vésiculaire; diamètre de 63 μ à 138 μ (8 mesurées).
Crochets du rostre: semblent absents.
Ventouses: diamètre approx. de 37 μ à 50 μ (2 mesurées).
Crochets embryonnaires: de 12 à 13 μ.
Hôtes: *Microcyclops varicans* Sars ♀ ♀ 11.
Mesocyclops leuckarti Claus ♀ ♀ 25, ♂ ♂ 2, jeunes 9.
Thermocyclops hyalinus (Rehberg) ♀ 1.
Localités: Nagaur; Didvana (Radjpoutana).
Dates de la récolte: Avril 5, 6 et 7, 1942.

Les Cystocercoïdes se trouvaient libres dans la cavité générale du corps des Crustacés et étaient aisément visibles à l'aide d'une loupe comme de petites masses denses d'un blanc nacré, chez les animaux conservés dans de la formaline. Ils occupaient le plus souvent le premier et le deuxième segment thoracique ou s'étendaient dans les trois premiers segments, ou bien ils étaient confinés au premier segment céphalothoracique. Plus rarement ils se trouvaient dans le deuxième et troisième segments ou dans les deuxième, troisième et quatrième segments thoraciques. En général ils étaient situés du côté dorsal et se trouvaient moins souvent vers le milieu du corps. Un spécimen occupait une position transversale, l'invagination tournée vers le dos. De 14 kystes examinés à ce propos 11 avaient le pôle antérieur dirigé vers la queue de l'hôte et chez 3 il pointait vers l'extrémité céphalique. Deux *Microcyclops varicans* portaient une infestation double; tous les autres cyclopes n'hébergeaient qu'un seul Cystocercoïde.

La cuticule du kyste était striée et assez épaisse. Les contours du scolex et du rostre se voyaient mal chez la plupart des spécimens. Deux ventouses se distinguaient difficilement chez quelques uns. Chez aucun je n'ai pu voir des crochets. L'appendice caudal semblait toujours de forme circulaire quand il pouvait se voir à l'intérieur de la nourrice. Après le dégagement il se déformait souvent et prenait des aspects irréguliers. Chez plusieurs je n'ai pu voir que deux des six crochets embryonnaires et chez d'autres quatre.

Cysticercus Hymenolepidis rugosae?

Longueur du kyste: 155 μ à 209 μ; moyenne 181 μ (22 mesurés).
Largeur du kyste: 76 μ à 130 μ; moyenne 108 μ (22 mesurés).
Configuration du kyste: allongée, ovoïde.
Queue: longue, assez mince.
Nombre des crochets du rostre: 8.

Longueur des crochets du rostre: 97 μ (du manche à la garde 48·5 μ; de la garde à l'extrémité de la lame 48·5 μ).
Hôte: *Thermocyclops hyalinus* (Rehberg) ♀ ♀ 47, ♂ ♂ 2, jeunes 2.
Localité: Nagaur (Radjpoutana).
Dates de la récolte:—Avril 5 et 6, 1942.

Ces Cystocercoïdes étaient également libres dans la cavité générale des Cyclopides et se voyaient facilement. Ils se trouvaient le plus souvent dans le premier et le deuxième segments thoraciques; dans plusieurs animaux ils s'étendaient dans les trois premiers segments et exceptionnellement ils ne dépassaient pas le premier segment céphalothoracique. La plupart occupaient une position dorsale. De 14 spécimens examinés au sujet de leur orientation l'invagination était dirigée vers la queue du cyclope chez 12, et vers sa tête chez 2. Chez tous les animaux infestés il n'y avait qu'un seul Cystocercoïde.

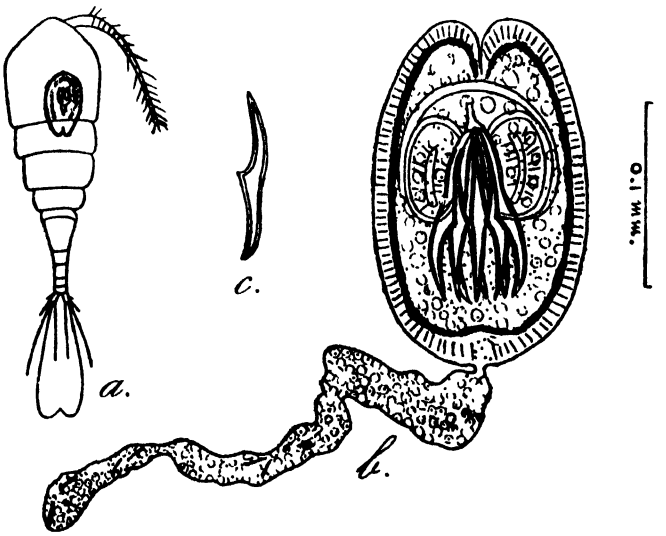


FIG. 2. *Cysticercus Hymenolepidis rugosae* ?

a, *Thermocyclops hyalinus* à Cystocercoïde in situ; *b*, Cysticercoïde dégagé; *c*, Crochet détaché.

La cuticule était semblable à celle de la forme précédente, mais moins épaisse. Les limites du scolex étaient peu distinctes mais deux ventouses se voyaient sans difficulté chez presque tous les spécimens examinés. Le faisceau des crochets était le plus souvent placé dans une position oblique. L'appendice caudal, en général entortillé, dépassait la longueur du kyste.

Ce Cystocercoïde ne fut dans aucun cas trouvé chez un hôte appartenant à quelque autre espèce que *Thermocyclops hyalinus*.

Cysticercus spec

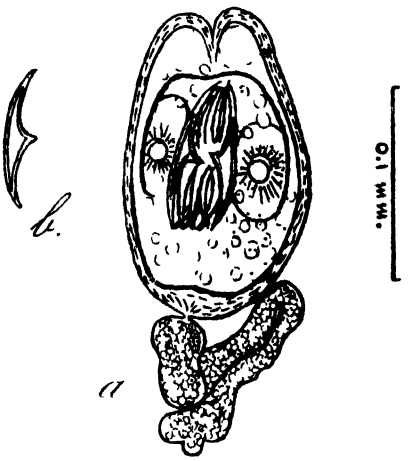


FIG. 3. *Cysticercus* sp. à 8 crochets.

a, Cysticercoïde dégagé, *b*, Crochet détaché.

Longueur du kyste: 138 μ à 183 μ; moyenne 167 μ (12 mesurés).
Largeur du kyste: 88 μ à 103 μ; moyenne 99 μ (12 mesurés).
Configuration du kyste: allongée, ovoïde.
Queue: longue, mince.
Nombre des crochets du rostre: 8.
Longueur des crochets du rostre: de 80 μ à 88 μ (la garde à peu près à distance égale entre l'extrémité de la lame et celle du manche).
Crochets embryonnaires: inférieurs à 12 μ.
Hôte: *Thermocyclops vermifer* Lindberg ♀ ♀ 24, jeunes 2.
Localité: Ahmédabad (Goudjerate).
Date de la récolte: Avril 9, 1942.

Toujours libres dans la cavité générale des cyclopes ces Cystocercoïdes se trouvaient le plus souvent dans la partie dorsale, soit du premier et du deuxième segment thoracique, soit dans les trois premiers segments. Dans trois cas le Cystocercoïde était confiné au premier segment céphalothoracique; un seul s'étendait dans une partie des quatre premiers segments thoraciques. Un spécimen unique parmi 14 observés à ce propos avait le pôle antérieur dirigé vers la tête de l'hôte. Des 26 animaux infestés 2 présentaient deux Cystocercoïdes chacun.

Je n'ai pas observé de striation radiaire de la cuticule; celle-ci était souvent bosselée et donnait des contours un peu irréguliers au kyste. Les limites du scolex étaient peu distinctes et les ventouses difficiles à voir chez la plupart des spécimens.

Les crochets, toujours au nombre de 8, etaient de longueur inégale chez des individus différents Dans les 12 cas où ils furent mesurés ils etaient longs de 80 μ chez deux, de 83 μ chez quatre et de 88 μ chez six L'appendice caudal, fortement replie et très fragile, surpassait la longueur du kyste Je n'y ai aperçu que deux des crochets de l'oncosphère et sans avoir pu les mesurer correctement

L'habitat dans lequel furent pêches les Cyclopides qui portaient ces Cystocercoïdes est le vieux reservoir hindou nomme le "baoli (puits à marches) de Dada Hari" à Ahmédabad En fait d'oiseaux, ce genre de réservoir ne semble guère être fréquente que par des pigeons C'est par consequent parmi eux qu'il faudrait rechercher le ver adulte

Cysticercus Hymenolepidis gracilis (Zeder)

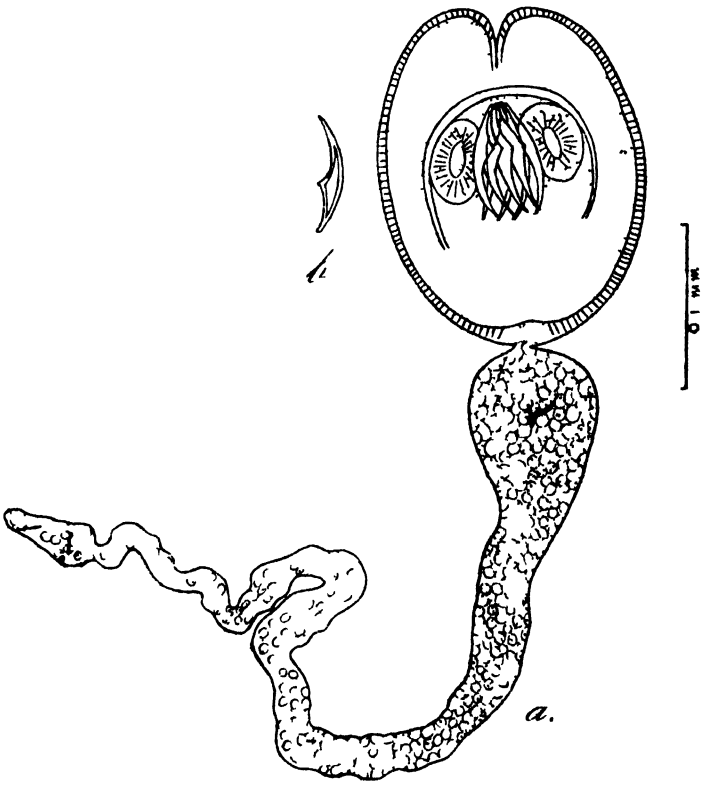


FIG 4 *Cysticercus Hymenolepidis gracilis*

a, Cysticercoïde dégagé, *b*, Crochet détaché

Longueur du kyste: 207 μ.
Largeur du kyste: 97 μ.
Configuration du kyste: ovoïde.
Queue: longue, environ 670 μ, à partie proximale renflée.
Nombre des crochets du rostre: 8.
Longueur des crochets du rostre: 75 μ (du manche à la garde 32 μ, de la garde à l'extrémité de la lame 43 μ).
Hôte:—*Diaptomus* sp. ♀ 1.
Localité:—Didvana (Radjpoutana).
Date de la récolte: Avril 7, 1942.

Je crois qu'on peut affirmer qu'il s'agit dans ce cas du Cystocercoïde de *Hymenolepis gracilis*, qui du reste a déjà été trouvé chez des *Diaptomus*, du moins en Europe.

TABLEAU MONTRANT LA PROPORTION DE CRUSTACÉS INFESTÉS.

NAGAUR. Etang Guinani.
Total examinés:
Microcyclops varicans ♀ ♀ 35, jeunes 2.
Microcyclops linjanticus ♀ 1.
Mesocyclops leuckarti ♀ ♀ 131, ♂ ♂ 3, jeunes 139.
Thermocyclops hyalinus ♀ ♀ 45, ♂ 1, jeunes 3.
Infestés:
Mesocyclops leuckarti ♀ ♀ 7, jeunes 5. *Cysticercus* sp. sans crochets. 4·4 pour cent.
Thermocyclops hyalinus ♀ ♀ 21, ♂ 1, jeunes 2. *Cysticercus Hymenolepidis rugosae*? 49 pour cent.
Thermocyclops hyalinus ♀ 1. *Cysticercus* sp. sans crochets. 2 pour cent.
NAGAUR. Puits du santon du Soufi.
Total examinés:
Mesocyclops leuckarti ♀ ♀ 86, ♂ ♂ 41, jeunes 199
Thermocyclops hyalinus ♀ ♀ 266, ♂ ♂ 17, jeunes 26.
Infestés:
Mesocyclops leuckarti ♀ 1, jeune 1. *Cysticercus* sp. sans crochets. 0·6 pour cent.
Thermocyclops hyalinus ♀ ♀ 26, ♂ 1. *Cysticercus Hymenolepidis rugosae*? 8·7 pour cent.
NAGAUR. Etang Djhara.
Total examinés:
Mesocyclops leuckarti ♀ ♀ 27, ♂ ♂ 5, jeunes 15.
Infesté:
Mesocyclops leuckarti ♀ 1. *Cysticercus* sp. sans crochets. 2·1 pour cent.
NAGAUR. Etang Lalsagar.
Total examinés:
Microcyclops varicans ♀ ♀ 2.
Mesocyclops leuckarti ♀ ♀ 338, ♂ ♂ 158, jeunes 213.
Thermocyclops hyalinus ♀ 1.
Infestés:
Mesocyclops leuckarti ♀ ♀ 3, ♂ 1. *Cysticercus* sp. sans crochets. 0·5 pour cent.
NAGAUR. Etang Samach II.
Total examinés:
Microcyclops varicans ♀ ♀ 504, ♂ ♂ 12, jeunes 228.
Microcyclops linjanticus ♀ 1.
Mesocyclops leuckarti ♀ ♀ 73, ♂ ♂ 14, jeunes 79.
Thermocyclops hyalinus ♀ ♀ 3, jeunes 2.
Infestés:

Microcyclops varicans ♀ ♀ 11. *Cysticercus* sp. sans crochets. 1·5 pour cent.
Thermocyclops hyalinus ♀ 1. *Cysticercus Hymenolepidis rugosae*? 20 pour cent.

DIDVANA. Etang Singui.
Total examinés:
Microcyclops sp. jeunes 14.
Mesocyclops leuckarti ♀ ♀ 277, ♂ ♂ 276, jeunes 513.
Diaptomus sp. Une dizaine.
Infestés:
Mesocyclops leuckarti ♀ ♀ 13, ♂ 1, jeunes 2. *Cysticercus* sp. sans crochets. 1·5 pour cent.
Diaptomus ♀ 1. *Cysticercus Hymenolepidis gracilis.*

DIDVANA. Tchanankoï, puits.
Total examinés:
Microcyclops sp. jeunes 2.
Mesocyclops leuckarti ♀ ♀ 2, jeunes 9.
Infesté:
Mesocyclops leuckarti jeune 1. *Cysticercus* sp. sans crochets. 9·1 pour cent.

AHMÉDABAD. Réservoir de Dada Hari.
Total examinés:
Mesocyclops leuckarti ♂ ♂ 2, jeunes 4.
Thermocyclops vermifer ♀ ♀ 28, jeunes 3.
Infestés:
Thermocyclops vermifer ♀ ♀ 24, jeunes 2. *Cysticercus* sp. à 8 crochets. 83·8 pour cent.

Cysticercus spec., *sans crochets.*

(1) Chez *Microcyclops varicans*:
Du total de 733 examinés d'un habitat à Nagaur, 11 infestés = 1·5 pour cent.

(2) Chez *Mesocyclops leuckarti*:
Du total de 1355 examinés de 4 habitats à Nagaur, 19 infestés = 1·4 pour cent.
Du total de 1077 examinés de 2 habitats à Didvana, 17 infestés = 1·6 pour cent.

(3) Chez *Thermocyclops hyalinus*:
Du total de 312 examinés de 4 habitats à Nagaur, 1 infesté = 0·3 pour cent.

Cysticercus Hymenolepidis rugosae?

Chez *Thermocyclops hyalinus* seulement:
Du total de 306 examinés de 2 habitats à Nagaur, 51 infestés = 14·2 pour cent.

Cysticercus spec., *à 8 crochets.*

Chez *Thermocyclops vermifer* seulement:
Du total de 31 examinés d'un habitat à Ahmédabad, 26 infestés = 83·8 pour cent.

Le taux d'infestation de ces quatre espèces de cyclopes est intéressant à observer et quelques remarques s'imposent à ce sujet.

Ce n'est pas toujours l'espèce prédominante qui montre l'infestation la plus élevée et les Cystocercoïdes différents ne semblent pas parasiter les Cyclopides sans distinction.

Il est évident qu'il existe une prédilection, soit chez le cyclope (l'entrée devant se produire par la voie buccale), soit chez l'embryon hexacanthe; ou bien c'est l'enkystement même qui ne puisse se produire que dans un hôte déterminé.

Ainsi c'est la question de la spécificité des Cyclopides dans leur rôle d'hôtes intermédiaires des helminthes qui se pose. Cette question a souvent été débattue au sujet du ver de Médine et j'ai montré que ce sont des *Thermocyclops* qui sont les hôtes habituels; ces *Thermocyclops* formant du reste presque toujours la grande majorité des Cyclopides habitant les puits, les réservoirs et les étangs où se fait la dissémination des embryons de *Dracunculus medinensis*.

Ici nous voyons que le *Cysticercus* sp. sans crochets, parasite aussi bien *Microcyclops varicans* que *Mesocyclops leuckarti*, mais est un hôte exceptionnel chez *Thermocyclops hyalinus*. Il est intéressant de relever que dans le puits du santon du Soufi à Nagaur ce Cystocercoïde infestait des *Mesocyclops leuckarti* mais était absent chez *Thermocyclops hyalinus*, bien que ces deux espèces s'y trouvaient en nombre à peu près égal.

Le Cystocercoïde présumé de *Hymenolepis rugosa* par contre s'est vu exclusivement chez *Thermocyclops hyalinus* bien que cette espèce était actuellement en minorité parmi les Cyclopides dans deux des habitats où se rencontrait ce Cystocercoïde (étang Guinani et étang Samach II).

Quand un *Thermocyclops*, soit *Th. hyalinus*, soit *Th. vermifer* fut trouvé parasité par un Cystocercoïde approprié cette infestation montrait un pourcentage élevé (dépassant 80 pour cent à Ahmédabad). Dans le cas de *Microcyclops varicans* et de *Mesocyclops leuckarti* par contre les taux d'infestation étaient toujours faibles.

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Liste des Cyclopides connus comme hôtes intermédiaires de Cestodes.

Nom du cyclope.	Nom du Cestode.	Auteur.
Eucyclops serrulatus (Fischer)	*Ichthyotaenia torulosa* (Batsch) ..	Richard.
	Hymenolepis fasciata (Krabbe) ..	Mrázek.
	Hymenolepis tenuirostris (Rudolphi) ..	Mrázek.
	Hymenolepis collaris (Batsch) ..	Mrázek.
	Hymenolepis coronula (Dujardin) ..	Rosseter.
	Hymenolepis microsoma (Creplin) ..	Richard, Rosseter.
	(*Cysticercus quadricurvatus*) ..	Rosseter.
Paracyclops fimbriatus (Fischer) ..	*Hymenolepis brachycephala* (Creplin) ..	Linstow.
Cyclops strenuus Fischer	*Ichthyotaenia torulosa* (Batsch) ..	Richard.
	Hymenolepis setigera Frölich ..	Linstow, Schmeil.
	Diphyllobothrium latum (Linné) ..	Rosen et Janicki.
Megacyclops viridis Jurine	*Hymenolepis gracilis* (Zeder, Krabbe) ..	Mrázek.
	Hymenolepis collaris (Batsch) ..	Mrázek.
Acanthocyclops vernalis Fischer.. ..	*Drepa idotaenia anatina* (Bloch) ..	Mrázek.
	Hymenolepis collaris (Batsch) ..	Mrázek, Daday.
Acanthocyclops bicuspidatus Claus ..	*Hymenolepis tenuirostris* (Rudolphi) ..	Mrázek.
Microcyclops varicans Sars	(*Cysticercus* spec. sans crochets) ..	Lindberg.
Mesocyclops leuckarti Claus	*Diphyllobothrium mansoni* (Cobbold) ..	Okomura.
	(*Cysticercus* spec. sans crochets) ..	Lindberg.
Thermocyclops hyalinus (Rehberg) ..	*Hymenolepis rugosa* Clerc ? ..	Lindberg.
	(*Cysticercus* spec. sans crochets) ..	Lindberg.
Thermocyclops vermifer Lindberg ..	(*Cysticercus* spec. à 8 crochets) ..	Lindberg.

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ARTICLE No. 4.

Un nouveau Cyclopide de l'Inde.

par KNUT LINDBERG.

Halicyclops electus, sp. nov.

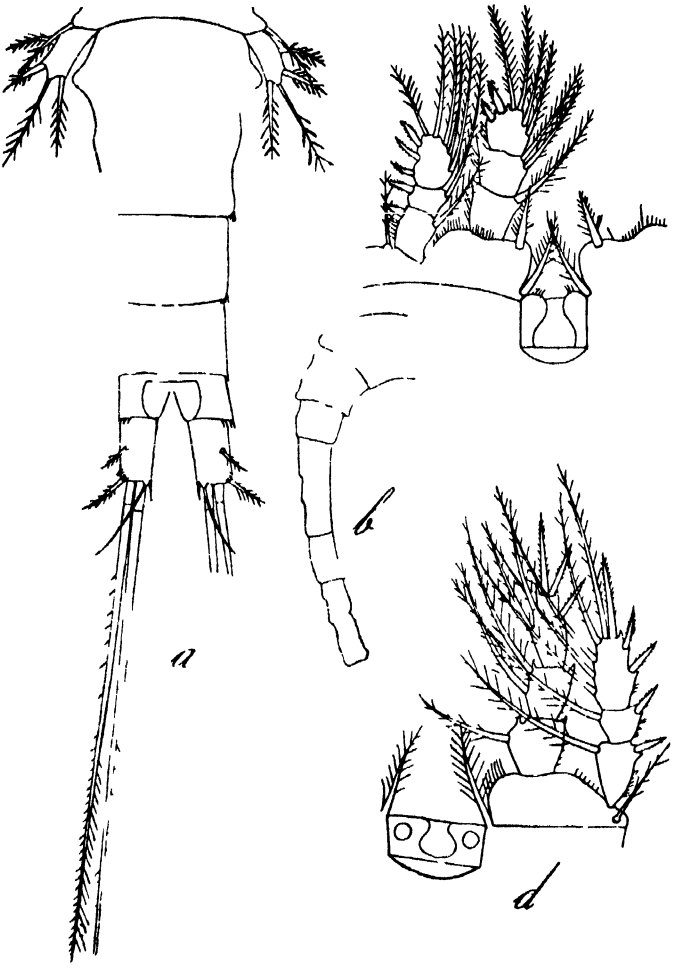
(*Communicated by Dr. Baini Prashad.*)

Description.—Forme grande et robuste. Longueur 969 μ, céphalothorax 617·5 μ, queue (abdomen + furca sans soies apicales) 351·5 μ; largeur 389 μ. Segment génital se rétrécissant très légèrement d'avant en arrière; les parties latérales présentent en avant du milieu du segment une forte protubérance obtuse. Bords postérieurs des quatre segments abdominaux munis de petites dents sur les parties latérales; la dentelure semble absente sur le milieu des bords postérieurs de ces segments. Branches de la furca légèrement divergentes, presque deux fois aussi longues que larges (57 : 30 μ = 1·90 : 1). Soie latérale externe divisant la branche de la furca dans la proportion 30 : 27. Soie dorsale longue (77 μ), prenant naissance sur une petite éminence prolongeant l'extrémité de la furca. Soie apicale externe assez courte; soie apicale interne rudimentaire. Soies apicales médianes bien développées, l'interne un peu moins que deux fois aussi longue que l'externe. Elles portent de petites épines sur les parties proximales et des cils distalement. Longueurs respectives des soies apicales 50 : 367 : 651 : 14 μ. Première antenne à 6 articles. Branches des pattes natatoires triarticulées. Formule des épines 3-4-4-3. Article 3 de l'enp. 4, près de deux fois aussi long que large (58 : 30 μ = 1·93 : 1). Epine apicale interne dépassant en longueur celle de l'article et considérablement plus longue que l'épine apicale externe. Epine apicale interne : épine apicale externe 67 : 49 μ = 1·37 : 1; épine apicale interne : article 67 : 58 μ = 1·16 : 1. Epine du rebord externe de l'article terminal de l'enp. 4 de structure normale; les soies du rebord interne de cet article ont également un aspect ordinaire. Lamelle basale assez peu élargie, considérant les fortes proportions de l'espèce. Soie des coins latéraux du rebord libre de cette lamelle longue et forte. Deuxième article de P 5 à épines minces et allongées, celle du bord interne étant la plus longue. Le réceptacle séminal n'a pas pu être distingué. Le spécimen unique ne portait pas d'ovisacs. Mâle inconnu.

Habitat.—Un marais à l'eau saumâtre à Mahim, faubourg de Bombay. Une seule femelle récoltée au mois de février 1941.

Remarques.—L'espèce remarquable qui vient d'être décrite ne ressemble à aucun *Halicyclops* dont la description m'est connue. Elle se rapproche le plus de *H. aequoreus* mais

s'en distingue par de nombreuses particularités, notamment sa taille plus grande, les protubérances du segment génital et les épines effilées de l'article 2 de la cinquième patte.



(*a*) P 5, abdomen et furca, face dorsale.
(*b*) Première antenne.
(*c*) P 1.
(*d*) P 4.

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ARTICLE No. 5.

Cyclopoïdes (Crustacés Copépodes) de l'Inde II.

par K. LINDBERG.

(*Communicated by Dr. Baini Prashad.*)

Eucyclops gibsoni (Brady).

Description.—Espèce plutôt petite. Longueur de la femelle ovigère de 703 μ à 798 μ; largeur de 243 μ à 266 μ. Ailes latérales du cinquième segment thoracique arrondies, peu prolongées, munies de fortes soies. Les bords postérieurs des trois premiers segments abdominaux semblent dépourvus de dentelures. Segment anal présentant deux types différents, étant chez les uns très fendu, chez d'autres l'échancrure anale est peu ouverte; je n'y ai pas observé de poils. Branches de la furca légèrement divergentes, de 5 à 7 fois aussi longues que larges; le plus souvent ce rapport est d'environ cinq fois et demi. Serra entièrement absente. Soie dorsale longue. La soie apicale externe n'est pas spiniforme ou l'est très peu; sa longueur est à peu près égale à celle de la soie apicale interne, ou plus souvent, légèrement inférieure à la longueur de celle-ci. Soies apicales médianes ciliées d'une façon régulière. Longueurs respectives des soies apicales de la furca d'un spécimen: 40 : 227 : 349 : 40 μ. Première antenne à 12 articles, rabattue elle atteint le milieu ou le bord postérieur du deuxième segment thoracique. Les trois derniers articles sont munis d'une membrane hyaline étroite et entière ou très finement denticulée. Soie marginale du dernier article insérée en arrière du milieu de l'article. Formule des épines 2-3-3-3. Article terminal de l'endopodite de la quatrième paire de pattes environ deux fois aussi long que large. Epine apicale interne nettement plus longue que l'épine apicale externe. Elle dépasse aussi en longueur celle de l'article. Mensurations de cet article chez un individu: Article, longueur : largeur 38 : 22 μ = 1·73 : 1. Epine apicale interne: épine apicale externe 48 : 38 μ = 1·26 : 1. Rebord libre de la lamelle basale de la quatrième paire de pattes dépourvu de poils. Les soies des angles latéraux présentent des cils longs sur les parties proximales et des cils très courts sur les extrémités. Cinquième patte à épine interne de longueur considérable (environ 40 μ et plus), égalant même en longueur celle de la soie médiane. Cette épine est cependant, peu élargie; elle est légèrement recourbée, à concavité du côté interne. Réceptacle séminal sans caractères distinctifs. Ovisacs appliqués contre l'abdomen,

ne dépassant pas la furca mais atteignant en général son tiers postérieur. Ils contiennent de 5 à 12 gros oeufs.

Mâle. Longueur 655 à 722 μ. Branches de la furca parallèles, sans serra, de 4·53 à 4·61 fois aussi longues que larges (2 animaux mesurés). Article terminal de l'endopodite de P 4 à épines apicales de longueurs plus considérables que celle de l'article. Chez un spécimen les mensurations de cet article étaient les suivantes. Article, longueur : largeur 37 : 20 μ = 1·85 : 1. Epine apicale interne: épine apicale externe 51 : 41 μ = 1·24 : 1. Sixième patte formée d'une épine interne relativement forte et très longue (de 50 à 60 μ), surpassant en longueur celle du deuxième segment abdominal et pouvant atteindre le milieu du quatrième segment abdominal; d'une soie médiane très courte et d'une mince soie externe de direction oblique.

Habitats.—Des mares du fleuve Sarasvati, en haut des chutes d'eau de Guersoppa (Etat de Maïsore) et des flaques d'eau de suintement en bas des cascades (décembre 1940). Une mare près d'un torrent à Kodaikanal, montagnes Palni, avec *E. euacanthus* Sars (janvier 1939).

Remarques.—Parmi les nombreux *Eucyclops* sans serra décrits jusqu' à ce jour la forme présente semble se rapprocher le plus de *E. gibsoni* (Brady) et je crois qu' il n'y a aucun doute qu'il ne s'agit, de la même espèce. La description et les illustrations de Brady laissent cependant beaucoup à désirer, mais Sars a en 1927 retrouvé la forme décrite par Brady en 1904 et en a donné une bonne description accompagnée d'excellentes gravures. Sars insiste cependant sur la structure des épines des exopodites des pattes natatoires chez le mâle, ces épines, notamment celles du P 3 et du P 4, devant être très fortes et à rebords lisses Chez les animaux de l'Inde je n'ai pas observé de particularité frappante chez les épines en question et leurs rebords étaient munis de cils courts comme c'est en général le cas. Les exemplaires que j'ai eu l'occasion d'examiner sont cependant plus petits que ceux de l'Afrique du Sud (Brady donnait 1 mm. comme la longueur de la femelle et Sars 1 mm. 2) et plusieurs ont une furca plutôt courte (moins de 6 fois aussi longue que large). Ces caractéristiques s'accordent avec celles données par Kiefer d'animaux rapportés de Java et de Bali et appelés par lui *E. gibsoni abbreviatus*.

Le *Cyclops nubicus* décrit en 1922 par Chappuis et récolté par lui-même dans le Soudan égyptien dans une mare près des bords du Bahr el Zeraf (affluent du Nil), dans un petit étang au sud de Fachoda et dans le Nil même, a depuis été considéré comme identique à *E. gibsoni*. Celui-ci a selon Kiefer été retrouvé aussi dans l'Afrique équatoriale.

Notre espèce a par conséquent une aire de répartion très étendue et sa présence dans le Sud de l'Inde ne manque pas d'intérêt.

Mesocyclops splendidus sp. nov.

Description.—Espèce grande et robuste. Longueur de la femelle 1160 μ (sans soies apicales). Bord postérieur du quatrième segment abdominal pourvu, sur la face ventrale, d'une rangée de petites épines, celles-ci s'étendant aussi sur les parties externes de la face dorsale. Furca à branches courtes, légèrement divergentes, environ deux et demi fois, ou moins de deux et demi fois, aussi longues que larges, à bord interne glabre. (Longueur : largeur 77 : 32 μ = 2·40 : 1). Soie latérale externe insérée un peu en arrière du milieu de la branche de la furca. Soie dorsale ciliée, dépassant légèrement en longueur celle de la soie apicale externe. Soie apicale interne un peu moins de trois fois aussi longue que la sole apicale externe. Longueurs respectives des soies apicales 102 : 409 : 576 : 275 μ. Première antenne à 17 articles, les deux derniers à membrane hyaline présentant des échancrures distalement au niveau du dernier article. Bord supérieur du deuxième article du maxillipède montrant un aspect perlé; le bord libre inférieur pourvu de deux petites soies au lieu d'une seule. Angle interne du deuxième article basal de la première paire de pattes muni d'une soie finement ciliée, courte mais assez forte. Lamelle basale de la quatrième paire de pattes présentant une dent assez grande et forte, dépassant le bord libre de chaque côté. Article terminal de l'endopodite de la quatrième paire de patte plus de deux fois et demi aussi long que large, à deux épines apicales, dont l'interne est un peu plus longue que l'externe (Article, longueur : largeur 83 : 30 μ = 2·77 : 1; épine interne: épine externe 53 : 52 μ = 1·21 : 1). Cinquième patte sans caractères distinctifs, à épine du deuxième article plus courte que la soie. Configuration du réceptacle séminal représentée sur la figure d'une façon approximative. L'unique spécimen manquait de sacs ovigères. Mâle inconnu.

Habitat.—Un étang eutrophique où abondaient les nénufars à Mahé (Côte de Malabar), Inde française. Récolté au mois de décembre 1940 avec d'assez nombreux *Mesocyclops leuckarti* Claus.

Remarques.—Comme il vient d'être dit il n'a été trouvé qu'un seul exemplaire de cette espèce remarquable.

Il est toujours peu satisfaisant d'avoir à caractériser une nouvelle forme d'après un individu unique et surtout lorsqu'il s'agit d'un proche parent d'une espèce telle que *M. leuckarti* qui est déjà très variable.

L'animal décrit ici présente cependant une particularité frappante qui à elle seule la différencie de toutes les formes variantes de *M. leuckarti*, la présence d'une soie au niveau du deuxième article basal de P 1.

L'absence ou la présence de cette soie, qui chez les Cyclopides est d'une grande constance, donne à cette particularité une valeur diagnostique. On peut rappeler à ce sujet la différ-

enciation de *Tropocyclops prasinus* (Fischer) et de *Tropocyclops confinis* Kiefer. Le spécimen étudié ici se distinguait d'ailleurs déjà à un examen superficiel des *M. leuckarti* parmi lesquels il se trouvait, de sorte que je l'en avais séparé aussitôt, croyant d'abord avoir affaire à un *Macrocyclops*.

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Sars, G. O., (1927). The fresh-water Entomostraca of the Cape province. *Ann. S. Afric. Mus.*, XXV, pp. 121–125.

Liste des figures.

Fig. 1. *Eucyclops gibsoni* (Brady).

a, ♀ Segment anal et furca; *b*, ♀ P 5 et segment génital; *c*, ♀ Première antenne, derniers articles; *d*, ♀ P 1; *e*, ♀ P 4; *f*, ♂ P 5 et P 6; *g*, ♀ Segment anal et furca; *h*, ♀ P 5 et segment génital; *i*, ♀ P 4.

a–f, Spécimens d'une mare du fleuve Sarasvati à Guersoppa. *g–i* Spécimen d'une flaque d'eau de suintement en bas des chutes d'eau à Guersoppa.

Fig. 2. *Mesocyclops splendidus* sp. nov. ♀

a, Furca; *b*, P 5 et segment génital; *c*, Base de P 1; *d*, Lamelle basale de P 4; *e*, Article terminal de l'endopodite de P 4; *f*, Première antenne, derniers articles; *g*, Extrémité du maxillipède.

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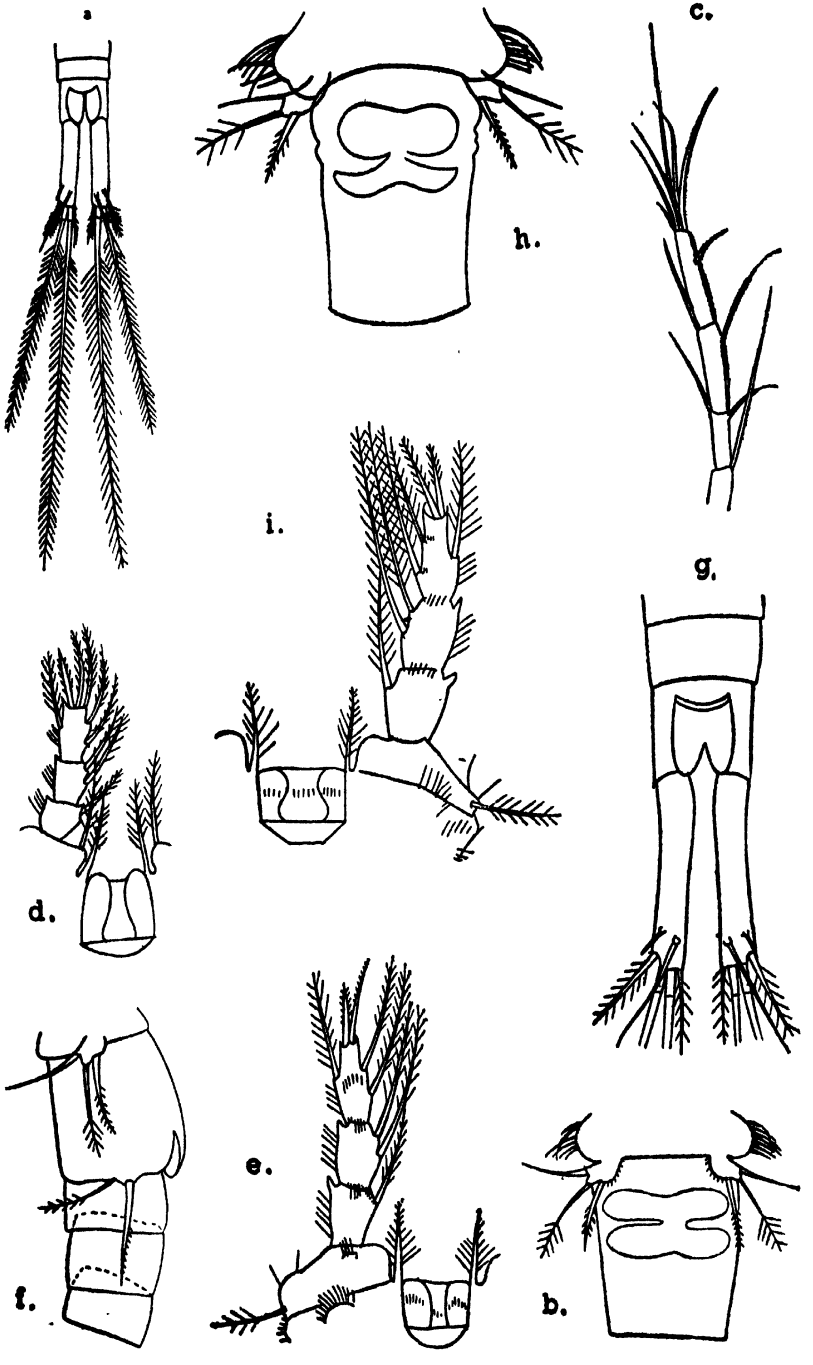


Fig. 1.

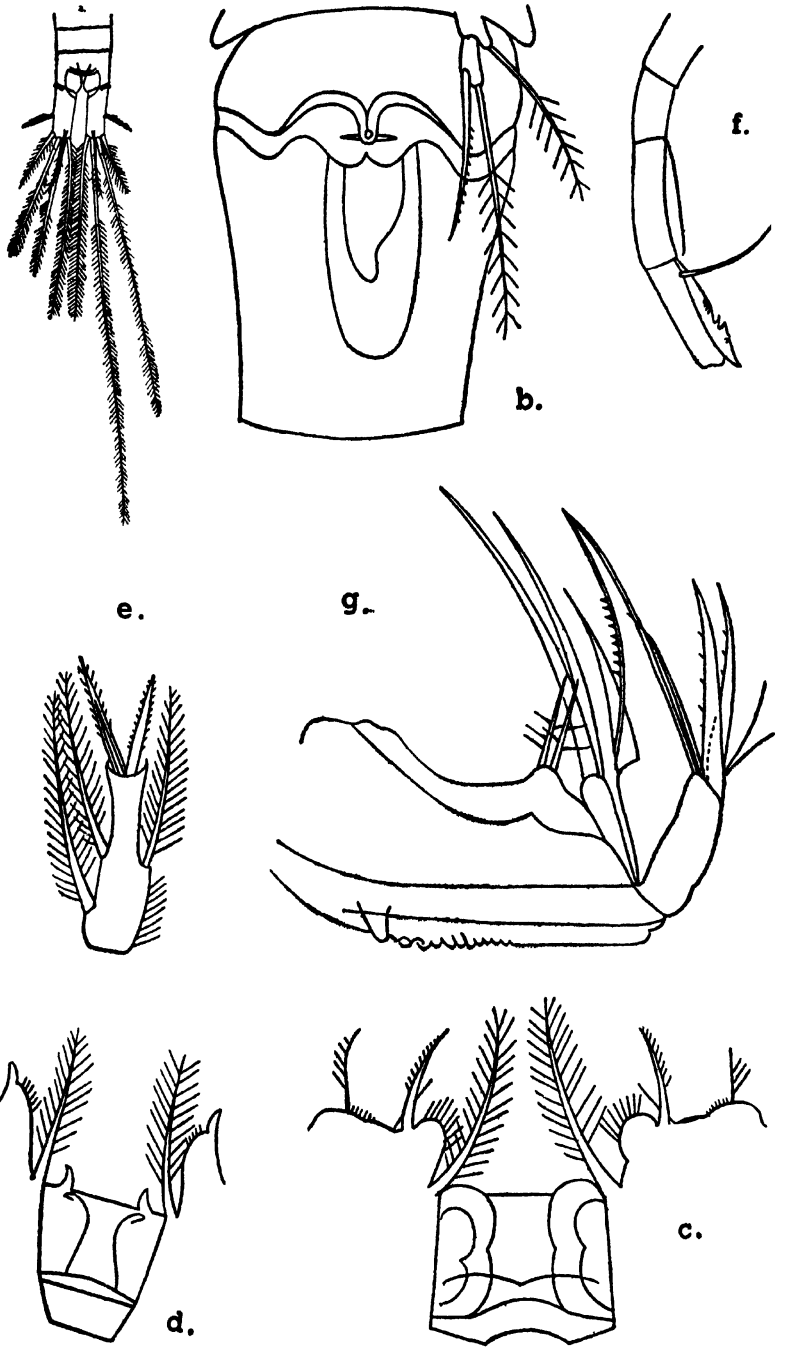


Fig. 2.

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ARTICLE No. 6.

Bengal Coiled Basketry.

By K. P. CHATTOPADHYAY.

Coiled basketry, of the types described in standard works, is associated with sewing in technique, just as ordinary plaited basket-work is linked to weaving. An important exception is formed by what may be termed Bengal coiled basketry. Here the technique is allied to carpentry. The Bengal coiled baskets are made of cane of the local variety. These canes do not easily split into strips, under the knife, like Malacca cane. On the contrary, when soaked in water, as is done for the Malacca variety before splitting them, the Bengal cane develops some mucilage and prevents easy slicing up into slips.

For the construction of a coiled basket, the bundle of cane is first of all soaked in water for a day and a night. The end



FIG. 1. Cane with end shaved off.

from which the work is to be started then has half its thickness shaved off with a knife, to a length of about a foot. It is next coiled into a spiral. At first as each half turn is completed a hole is made with an awl (Phoṇṛ), and a small bamboo pin is driven in (sketch 1*a*) to keep the two portions together. The

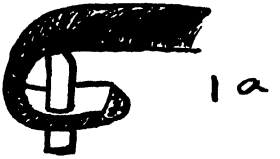


FIG. 1*a*. The first half coil with *Khil*.

blow is given with a wooden hammer and has to be sharp and firm; otherwise the point of the bamboo nail (Khil) cannot go through and is damaged. As indicated in the sketch (sketch 1*k*), the *Khil* is wedge-shaped near the point, but rectangular above it. The *Khil* is made from bamboo strips, with the skin of the bamboo whole, on one side. For the lower portion of the coil,

near the base, short and narrow pins (Khil) are used, about three-fourths of an inch long and less than a quarter inch wide. For



FIG. 1*k*. *Khil* or bamboo pin, actual size.

the upper layers, larger *Khils*—nearly an inch and a half long and a quarter of an inch wide—are employed.

Owing to the shape of the *Khil*, it cannot go through the second coil easily, while the next coil, pressing on the head of the nail, prevents it from coming out. At first, the smaller *Khils* pierce and bind together only two coils, of half the thickness of the cane. As the whole cane is reached, the larger pins are used, and hammered in every three or four inches. The *Khil* generally pierces three coils at once, but sometimes only two may also be thus pinned together. Coiled baskets of this type invariably have a somewhat flat bottom, rising into sloping sides to form a hemispherical bowl-like shape. Sometimes, the top portion may even bend inwards to some extent. The base is made by simply superposing one coil fully on the one preceding and pinning them together as described below. In the flat portions the *Khil* is driven in, holding it in the plane of the coil but inclined to the edge of the cane (sketch 1*b*), away from the direction in



FIG. 1*b*. *Khil* inserted at an angle.

For convenience of illustration, the adjacent coils have been drawn separated by gaps. Actually they are pressed together. For the same reason, only one pin has been shown in 1*b*.

which the coil is proceeding. The straight edge of the point of the *Khil* remains on the inner side, describing by this expression the side on which the work has been completed. The pull of the two coils bound by the *Khil* does not allow it to straighten up and get loose. If the pin had been fixed inclined the other way, the pull of the coils would have sent them apart and loosened the pin.

After the base has been built up in this fashion the sides have to be constructed, sloping or bulging outwards. For this purpose, the cane of each new coil is placed outwards with only half of it on the preceding coil, and the other half projecting outside. For a slope inwards, the new coil is placed only half inside. In both the cases, the *Khil* is driven straight down, holding it in the plane of the two adjacent coils. For an outward bulge, the *Khil* is driven inward, and conversely, for a slope the other way. At the end, the cane is again shaved off for a short length and fixed firmly by pins, the end going under a coil. For greater firmness the basket is bound with cane slips radially. The projecting points of the *Khils* are then trimmed off. The flat base, it is to be noted, is sometimes made slightly concave to start with, to ensure greater stability to the basket. The firm layers of cane generally make these baskets practically watertight.

The hemispherical baskets are known in Bengal as *dhāmā* (sketch 2) and are used mostly for storing and carrying grain.

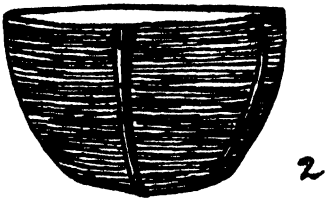


FIG. 2. The Bengal coiled basket *dhāmā*.

Small baskets of standard size are made for measuring grain. These are known as *Kunke* or *Rek*, and hold one-third of a seer. They have a flat base, rising with an outward bulge and ending in a slope inwards, to form a comparatively narrow aperture. Pans of bazar balances, used by grain-sellers, are also often made in this fashion. These are shallow concave circular pieces. Shields are also made in the villages in Bengal in this manner. First of all a convex circular plate is made, and then a slightly concave edge is added, the entire shield being one foot and a half to two feet in diameter. The whole of it is then strengthened with cane slips. A handle of such strips, or of rope is made inside. These shields were used in the old days (before fire-arms became common) in fighting. The warrior generally

carried one of these shields (Dhāl) and several long narrow simple spears of bamboo (Sarki), with the point hardened in fire. They have survived in the outlying villages and are even now used in displays and occasional fights.

From enquiries made by the writer in Midnapore (West Bengal), 24-Parganas and Nadia (Central Bengal) and Faridpore (East Bengal) it appears that these baskets are made only by the cobbler caste known as *Muci* or *Riṣi* as they prefer to style themselves. The Dom, who works on bamboo, and also with cane slips to make and mend modern furniture, is not acquainted with this technique and does not take to it. The Mahali basket-weavers of Chotanagpore are also not acquainted with it.

A certain amount of coiled cane basketry is done also in Northern India outside Bengal. But these are made in the usual way, by tying or sewing the coils with slips of cane or other material. The cane helmets made by some of the Assam hill tribes are also built up without pins. The special mode of making coiled basketry described in this note, therefore, seems to be peculiar to Bengal. The method of pinning adjacent coils is comparable to the fitting together of planks in carvèl-built boats.

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ARTICLE No. 7.

Systematic Position of a Common Tree Fern of the Eastern Himalaya with a note on the genus Cyathea.*

By K. BISWAS.

There exists considerable confusion regarding the classification of the Ferns and Fern-allies of India and Burma. The author, as a result of his examination of thousands of specimens in the Herbaria of Calcutta, Kew, British Museum (Natural History), London and Edinburgh, finds that many genera, if not families, of ferns need critical and careful revision.

Names of several species of tree ferns of the Eastern Himalayas belonging to the genus Cyathea appear to be dubious. In fact, the position of the genus Cyathea itself is uncertain. Copeland advocates reduction of the genera *Alsophila* and *Hemitelia* to *Cyathea* on the ground that no natural separation can be made on the structure of indusial characters. Cyathea is characterized by completely covered indusium, whereas Alsophila is distinguished by the entire absence of indusium, and Hemitelia stands in between with its hairy, partially covered, sub-calyciform or one-sided indusium. No other well-marked distinguishing permanent morphological characters have been recorded so far which justify separation of these three groups of tree ferns. The revision of the genus Cyathea has, therefore, resulted in establishing a set of hair-splitting differences. But judged from the character of indusium alone, such differences are not of sufficient practical value. The indusial characters together with the general nature of the fronds and differentiating characters of the segments and nature and growth of the trunk and costa are important characters to be taken into account in retaining or reducing the three genera. I consider the genus Cyathea as a genus distinct from *Alsophila* and *Hemitelia*.

Holttum [5] follows Copeland's view of combining the three genera into one—namely, *Cyathea*. Christensen [2] keeps the three genera distinct and remarks, 'In my opinion Domin is wrong, however, in transferring all species to *Cyathea*.'

The different *forms* or *varieties* of the tree fern, *Cyathea spinulosa*, one of the most common tree ferns in the Sikkim Himalaya, have hitherto been considered as three or more distinct species under different names. John Scott [6] separated *Cyathea decipiens* (Scott) Clarke & Baker, from *C. spinulosa*

* Read at the 29th Session of the Indian Science Congress Association at Baroda, 1942.

and made it a new species of the genus *Hemitelia—H. decipiens* Scott. Clarke and Baker[4] considered it to be a species of *Cyathea*. Beddome[1] described it as *Amphicosmia decipiens* Bedd. Carl Christensen records the specific name as *Cyathea decipiens* (Scott) Clarke & Baker. Beddome remarks, 'I do not feel certain it is distinct from *Cyathea spinulosa* as I have not seen the involucre in very young state.' C. B. Clarke[3] rightly remarks, 'I have no hesitation with J. Scott's description, figures and type specimen before me in uniting *C. spinulosa* J. Scott to *H. decipiens*. The two are so far as I can see identical.' Apart from the minor distinctions pointed out by Scott the main difference between *C. spinulosa* and *H. decipiens* as described by him is the membranous, deciduous, sub-calyciform structure of the involucre which sometimes is in the form of a scale at the base of the sorus. This character is based on his type sheet—which is an old one bearing a portion of the frond with mature burst sori and hence the involucre is in the form as described above by him. The other specimens of *H. decipiens*, such as those of Clarke No. 26359, 1875 and J. S. Gamble 281A from Kalimpong—Bhutan, 4,000 ft., gathered from the same plant as No. 26359 of Clarke, indicate that the involucre covers the sori completely in the younger stages. Beddome rightly doubted the status of *H. decipiens* of Scott as a different species from *C. spinulosa*. As a result of my examination of the Herbarium materials of *Cyathea* and *Hemitelia* at Kew, British Museum (Natural History), Edinburgh and Calcutta Herbarium and numerous living plants at various stages of growth in their natural habitats in such localities as Sikkim (proper), Mungpoo, Kalimpong, Darjeeling and its neighbourhood at different elevations, I consider *H. decipiens* of Scott (*C. decipiens*) to be only a *form* of *Cyathea spinulosa* Wall. Minor variations in morphological characters observed by Scott are due to age and climatic and edaphic conditions. These characters do not, therefore, justify specific rank of Scott's *H. decipiens*. On the above grounds, I consider *Cyathea decipiens* to be identical with *Cyathea spinulosa*, the widely distributed Asiatic species. In my description of the species in this paper I have incorporated all the variations observed in different ecological forms of the plants examined by me in dried state and found growing under different conditions between 1,000 and 8,000 ft. in the shady sub-tropical or sub-temperate temperate rain forests of the Eastern Himalayas.

Cyathea Brunoniana (Wall.) Cl. (*H. Brunoniana*) also appears to be a *form* of *C. spinulosa*. *C. spinulosa* has thus only two different *forms*, namely, *forma-decipiens* and *forma-brunoniana*. In addition to these two *forms* a variety—*Var. Scottii*—can be taken as a distinct variety if not a species as suggested by Clarke and Baker.

Key to the varieties and forms of *C. spinulosa*—Lofty tree fern, caudex simple or dichotomously branched with strongly

armed deep brown or purple stipes; fronds unbranched, pinnate or decompoundly pinnate.

Veins 1–3 forked or pinnate with 3–5 veinlets, indusium covering the whole sorus or breaking irregularly as semi-calyciform bilobed cupule *C. spinulosa.*

A. Veins with many 3-branched veinlets concomitant with the deeper crenations of the pinnules *C. spinulosa var. Scottii* Clarke.

B. Veinlets 2-4 branched, involucre globose.

(*a*) 3–4 branched, indusium deciduous, hemispheric cup varying in size from a small scale at the base of sorus to large semi-calyciform lobed or irregularly broken structure .. *forma-decipiens.*

(*b*) Veinlets 2-branched, rarely 3-branched, indusium, a shallow cup soon breaking down to sub-petalliform scale, finally appearing as a half-cup with lacerate margin *forma-brunoniana.*

Cyathea spinulosa Wall.

Synonyms:—*C. decipiens* (Scott) Clarke & Baker in *Journ. of the Linn. Soc.* (Bot.), Vol. XXIV, p. 409, 1888; *Amphicosmia decipiens* (Scott) Beddome, F.B.I., p. 10, 1883; *Hemitelia decipiens* J. Scott, in *Trans. Linn. Soc.*, Vol. XXX, p. 33, t. 14, 1875.

A tall tree fern 30–40 ft. high, caudex sometimes dichotomous, stipes brown, deep brown or purple, strongly aculeate, paleaceous towards the base, muricated, furfuraceous and of a pale brown colour upwards; the aerial stem below always covered by matted mass of strong adventitious roots and upwards with the strongly armed bases of the persistent stipes, terminating in a beautiful crown of pale green younger fronds; fronds 10–12 ft. long, glabrous, somewhat coriaceous, sub-flaccid with small bullate scales on the costules, unbranched, pinnate or decompoundly pinnate, tripinnatifid, primary pinna 20–30 in. long, 9–12 in. broad, oblong lanceolate, acuminate, pinnules 4–8 in. long and ¼–1 in. broad, segments linear-oblong, acute, falcate, serrate or serrulate, with or without bullate scales on the costules beneath;

veins 1–3 forked or pinnate, with 3–5 veinlets, receptacle elevated, globose; sori conspicuous, copious, close to the costules and below or upon the axil of the lowest fork; indusium or involucre globose, covering (when young) the whole sorus, thin, membranous, fragile and soon breaking irregularly appearing as semi-calyciform bilobed cupule.

Distribution in India and Burma.

In the Himalayas from Nepal to Burma; abundant in Sikkim (Mungpoo), Khasia and Jaintia Hills from 2,000 ft. to 6,000 ft. in elevation. It is also reported from the Madras Presidency—Vizagapatam, Rampa Hills (2,000 ft.), Malabar and Canara; Central Provinces (Pachmarhi) and Burma, Amherst District, Taok, Downe Hills, 3,500 ft., J. H. Lace. Wallichian Sheet No. 178 bears specimen from 'Nepal montibus, 1821'. Burma between Sadon and the Yunnan Chinese border at Chingtitong and Kambaiti, 1922, J. F. Rock.

Cyathea spinulosa Wall. *var. Scottii* Clarke.

It is perhaps a distinct species as noted by Clarke and Beddome (cf. Clarke, *Trans. of the Linn. Soc.*, Series 2, Vol. 1, p. 431, 1880), the larger pinnules with many distinctly 3-branched veinlets concomitant with the deeper crenation is sufficiently quite distinct character to separate it as a species. But further field observations would be necessary before giving it a status of a distinct species. For the present I consider it to be a distinct variety as Clarke has adopted.

Forma-decipiens (Scott) Clarke & Bak.—A lofty tree fern about 30–40 or more ft. high, stipes of mahogany brown colour, strongly aculeate at the base, very prickly on the main and secondary rachises, tertiary rachis (that of the pinnules), bullate scaly, not pubescent; fronds 10–12 ft. long, more or less coriaceous, greyish green; pinnules 4–8 in. long, ¾-1 in. broad, glabrous or nearly so, segments linear-oblong, acute, falcate, serrate, sometimes much narrowed where fertile; veinlets forked or often 3-branched and even 4-branched in the sterile portions; sori prominent, copious in two rows close along the main veins or costule of the segment; involucre deciduous, a hemispheric cup varying in size from a small scale at the base of the sorus to large semi-calyciform—2-leafed or irregularly broken. J. Scott in *Linn. Trans.*, XXX, 33, t. 14; Bedd., F.B.I., *Amphicosmia decipiens* (J. Scott under *Hemitelia*), p. 10, 1883; his t. 311 shows the veins and bullate scales correctly, but not the involucre (after Beddome). 'Differs from the next in being much more prickly and in the segments being generally longer and narrower. I do not feel certain it is distinct from *Cyathea spinulosa* as I have not seen the involucre in very young state.'—Beddome.

Distribution in India and Burma.

Sikkim and Bhutan, 1,000 to 4,000 ft. Khasia below Nungklow. Central India (Pachmarhi, Mrs. Morris' 1883). India bor. Recorded for the first time from Burma.

C. B. Clarke and J. G. Baker in their contribution 'Supplementary Note on the Ferns of Northern India', *Journ. of the Linn. Soc.* (Bot.), Vol. XXIV, p. 409, 1888, adopted the present nomenclature.

Forma-brunoniana (Wall.) Clarke et Bak.—A large tree fern usually 10–25 ft., sometimes up to 30–40 ft. high with a sub-horizontal crown; prickly and muricated upwards. Fronds pinnate, rachis of pinnae often free from prickles; rachis of pinnules beneath more or less crisped; veinlets 2-branched, rarely 3-branched; indusium membranous—at first globose, soon breaking down and reduced before the sori are ripe to a hemispheric cup or sub-petalliform scale appearing as a half cup with lacerate margin while the spores are dispersing. Sori close along the main vein or costule of the segment. *Amphicosmia Brunoniana* (Wall. under *Alsophila*) Bedd., F.B.I., p. 10. Beddome notes, 'The specimens for which Mr. Clarke gives the locality "Deccan" is a specimen of *Cyathea spinulosa* collected at Mendeb in Canara by Dr. Richie.'

General Distribution in India and Burma.

East Nepal—Sikkim to Bhutan extending abundantly in Khasia and Manipore (1881, Wall!), Burma, 4,000 to 8,000 ft. in elevation. Mergui? Griffith? Between Sadon and Yunnan border No. 7464, F. Fock. In India—East Himalaya to Burma and Yunnan.

This form is recorded here for the first time from Burma.

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Two specimens of old trees of the Tree Fern *Cyathea squamulosa* Wall. as grown in the Lloyd Botanic Garden, Darjeeling

Photo by K. Biswas

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ARTICLE NO. 8.

Observations on two Coccidia, Eimeria trionyxae n.sp. and Eimeria triangularis n.sp., from the Intestine of the Turtle Trionyx gangeticus Cuv.

By MUKUNDAMURARI CHAKRAVARTY *and* AMIYA BHUSAN KAR.

(*Communicated by Dr. K. Biswas.*)

With a view to study the protozoan parasites of the turtles, two specimens of *Trionyx gangeticus*, purchased from one of the Calcutta markets, were examined. The first specimen harboured the oöcysts of two distinct species of *Eimeria* in its alimentary canal, while the second one was infected with one of them alone. From the literature extant on the subject, we find that only eight species of *Eimeria* are known from the turtles and tortoises up till now. They are: *E. delagei* * (Labbé, 1893) from *Emys orbicularis* (*Cistudo europea*); *E. legeri* (Simond, 1901) from *Lissemys punctata granosa* (*Emyda granosa*); *E. mitraria* † (Laveran and Mesnil, 1902) from *Chinemys* (*Damonia*) *reevesii*; *E. brodeni* Cerruti, 1930, from *Testudo graeca*; *E. dericksoni* and *E. amydae* Roudabush, 1937, from *Amyda spinifera*; *E. chrysemedis* Deeds and Jahn, 1938, 1939, from *Chrysemis marginata*; and lastly, *E. koormae* Das-Gupta, 1938, from *Lissemys punctata*. Of these, only two (*E. legeri* and *E. koormae*) are from India and only one (*E. mitraria*) from Ceylon.

The coccidian parasites described in this paper are new to science as they do not resemble any known species of *Eimeria* and so far no other coccidian parasite has been reported from this turtle. We have named the coccidians *Eimeria trionyxae* and *Eimeria triangularis* after the host and the shape of the oöcyst respectively.

DESCRIPTION.

1. *Eimeria trionyxae*‡ n.sp.

The oöcysts were found in large numbers in the rectum of the turtles. The majority of the oöcysts contain within them the unsegmented zygote which eventually gives rise to the sporoblasts, a residual body being left at the centre. Both the immature and the mature oöcysts are spherical in shape like that of *E. legeri* and *E. koormae* and measure 14·42–18·54μ,

* *E. delagei* var. *marginata* has been reported from *Chrysemis marginata* by Deeds and Jahn, 1938.

† Also reported by Deeds and Jahn from *Chrysemis marginata*, 1938.

‡ The second specimen of *T. gangeticus* was heavily infected with this coccidian only which enabled us to describe the endogenous stages.

with an average of 16·48μ. The unsegmented zygote, measuring 12·36μ, is also spherical and contains a large number of refringent globules (fig. 1).

The four sporoblasts, when first formed, are oval in shape with a granular cytoplasm; later they are surrounded by a membrane and are transformed into a sporocyst (figs. 2, 3). The latter when fully formed, is pyriform in shape having rounded posterior and pointed anterior ends, unlike that of *E. legeri* and *E. koormae*. The sporocysts measure 12·36$\mu \times$6·18μ. The sporoplasm within the sporocysts becomes differentiated into two narrow and elongated sporozoites having rounded posterior and tapering anterior extremities. The sporocystic residue is also present (fig. 4).

The endogenous stages are scattered throughout the epithelial cells of the intestine of the host. The sporozoites infesting the epithelial cells could not be found by us. The earliest forms observed are the trophozoites, measuring 7·42$\mu \times$4·12μ; they are ovoid bodies with one of the ends rounded and the other tapering (fig. 5). The tapering end, which seems to be the anterior, stains dark and is directed towards the submucosa. The spherical nucleus is placed near the middle region of the trophozoite.

The schizonts, measuring 8·24–14·42μ in longest diameter, are spherical or oval in shape and contain a large number of deeply stained nuclei of uniform size (fig. 6). When fully matured they give rise to the merozoites.

The arrangement of the merozoites is a constant feature. They are arranged with one of their ends, presumably the anterior, directed towards the periphery of the mature schizont while their posterior ends converge towards the centre (fig. 7). This can be compared to the rosette formation. There is a cytoplasmic residue at the centre of the schizont. A fully formed merozoite (fig. 8) has an elongate club-shaped body, with the anterior end slightly tapering than the posterior, which is rounded It has a clear homogeneous cytoplasm and a centrally placed nucleus which is rectangular in shape, a character peculiar to this coccidium. The merozoites measure 4·12–6·18μ in length and about 1μ in breadth.

Although the mature microgametocytes have the same form as the schizont, they can be easily distinguished from the latter by the structure of the nuclei. The nuclei are smaller in size and vesicular in structure (fig. 9). Later they become elongated giving rise to thread-like bodies, the microgametes (fig. 10). The latter consist of a small rod-like body with a long flagellum attached to one end.

The macrogametocytes can be easily distinguished from other endogenous stages by the granular nature of the cytoplasm (fig. 11). The macrogametes are spherical in shape with a circular nucleus. The nucleus has a nuclear membrane and a

small karyosome placed eccentrically within it. In a fully mature macrogamete the nuclear membrane becomes drawn out into a cone at one point and the cytoplasm shows patches of darkly stained granules (fig. 12).

Diagnosis.

Systematic position—*Eimeria trionyxae* n.sp. (Coccidiida, Eimeriidae.

Diagnostic characters—Oöcysts are spherical measuring 14·42–18·54μ, with an average of 16·48μ; sporocysts measuring 12·36$\mu \times 6 \cdot 18\mu$, are pyriform in shape having pointed anterior and rounded posterior ends; both oöcystic and sporocystic residue are present; the sporozoites are narrow and elongated with a centrally placed nucleus; the merozoites have a clear cytoplasm and a rectangular nucleus; the sporulating schizont is a typical 'rosette'.

Host—*Trionyx gangeticus* Cuv.

Seat of infection—Intestine.

Locality—Calcutta.

2. *Eimeria triangularis* n.sp.

Only a few oöcysts were found in the rectum of the first specimen of the two turtles examined. No endogenous stage of this coccidium could be seen by us.

The oöcysts are triangular in shape with the sides arched (fig. 14). Some of the oöcysts, however, sometimes appear somewhat spindle-shaped (fig. 13) as seen at certain angle. The zygote within the immature oöcyst is spherical in outline and contains several refringent globules as in the other form. The oöcysts measure 10·3–14·42μ in longest diameter. They are without any micropyle and oöcystic residue.

The sporoblasts are developed from the unsegmented zygote if the oöcysts are kept in 1% chromic acid solution for one day. The sporocysts are oval when they first appear, but become spindle-shaped as soon as they mature (fig. 15). The sporocystic wall is very thin and the sporocyst contains two elongated sporozoites having a residual mass in between them. The sporocysts measure 10·3$\mu \times 4 \cdot 12\mu$.

Diagnosis.

Systematic position—*Eimeria triangularis* n.sp. (Coccidiida, Eimeriidae).

Diagnostic characters—Oöcysts are triangular in shape measuring 10·3–14·42μ in longest diameter; sporocysts are spindle-shaped and measure 10·3$\mu \times 4 \cdot 12\mu$; sporozoites are elongated bodies; only sporocystic residue is present.

Host—*Trionyx gangeticus* Cuv.

Seat of infection—Intestine.

Locality—Calcutta.

Comparative diagnostic characters of different species of *Eimeria* from turtles and tortoises is given in the following table.

We are indebted to Mr. D. Mukherji, who helped us in various ways. Thanks are also due to Prof. H. K. Mookerjee for permitting one of us (A. B. Kar) to carry on research work in this laboratory.

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Explanation of Text-figures.

All figures are magnified 1666 times except otherwise stated.

Figures 1–12. *Eimeria trionyxae* n.sp.

Fig. 1—An immature oöcyst from a fresh smear.
Figs. 2 & 3—Oöcysts showing the formation of the sporocysts from fresh smear.
Fig. 4—A fresh mature oöcyst. Oöcystic residue not shown.
Fig. 5—A trophozoite from a section.
Fig. 6—A schizont showing nuclei of uniform size from a section.
Fig. 7—A group of merozoites from a section. Note the rosette-like arrangement of the merozoites.
Fig. 8—A stained merozoite. ×3500.
Fig. 9—Microgamete formation from a section.
Fig. 10—Microgametes from a section.
Fig. 11—A macrogametocyte from a section.
Fig. 12—A mature macrogamete from a section.

Figures 13–15. *Eimeria triangularis* n.sp.

Fig. 13—An early oöcyst from a fresh smear.
Fig. 14—A fresh mature oöcyst.
Fig. 15—A single sporocyst showing the sporozoites from a fresh smear; sporocystic residue not shown.

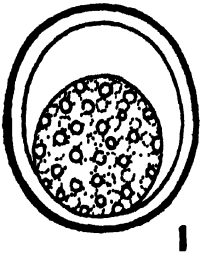
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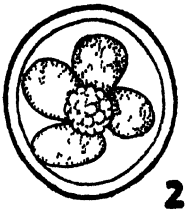
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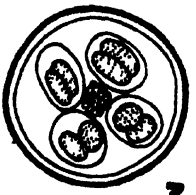
TABLE I.

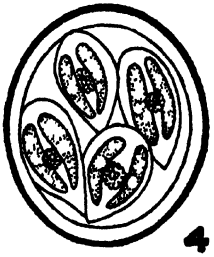
Parasite.	Oöcyst.			Sporocyst.			Locality.	Host.
	Form.	Size in micron.	Residue.	Form.	Size in micron.	Residue.		
E. delagei * (Labbé)	Ovoid	22× 16-17	Present	Oval		Present		*Emys orbicularis.*
E. legeri * (Simond)	Spherical	16–18	Absent	Oval		,,	India	*Lissemys punctata granosa.*
E. mitraria (Laveran and Mesnil).	Mitre-like with four or five ornamental projections.	10–15 in diam.	,,	Ovoid		,,	Ceylon and Okoboji, U.S.A.	*Chinemys reevesii* and *Chrysemis marginata*
E. brodeni Cerruti		18–20× 28–32						*Testudo graeca.*
E. amydae Roudabush.	Oval	16·72–23·66× 12·32–16·72 with an average 19·55× 14·60.	Present	Elliptical	2/3 of oöcyst	Present	U.S.A.	*Amyda spinifera.*
E. dericksoni Roudabush.	Sub-spherical	12·32–16·72× 10·56–15·84 with an average of 14·55× 12·88	,,	,,	½ of oöcyst	,,	,,	,,
E. chrysemidis Deeds and Jahn.	Oval	23× 15					Okoboji, U.S.A.	*Chrysemis marginata.*
E. hoormae Das-Gupta.	Spherical	14	Absent	Spindle-shaped	10× 4·5	Present	Jessore, Bengal.	*Lissemys punctata.*
E. trionyxae n.sp.	,,	14·42–18·54 average 16·48	Present	Pyriform with pointed anterior and rounded posterior ends.	12·36× 6·18	,,	Calcutta	*Trionyx gangeticus.*
E. triangularis n.sp.	Triangular	10·3–14·42 in longest diameter.	Absent	Spindle-shaped	10·3× 4·12	,,	,,	,,

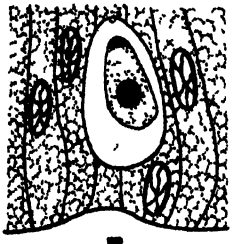
* The description of sporocysts are taken from the figures.

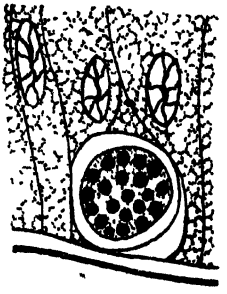

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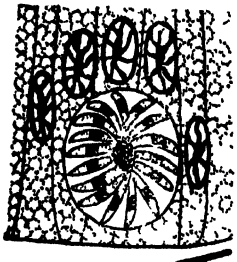

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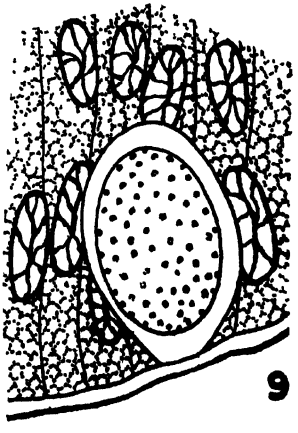

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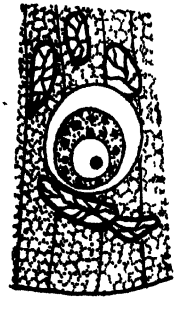

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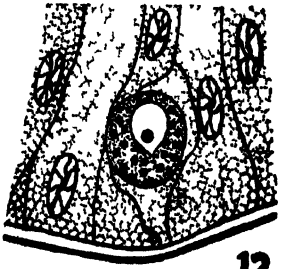

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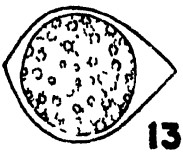

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ARTICLE No. 9.

Notes on the dorso-lumbar veins in the common Indian toad *Bufo melanostictus* Schneider.

By JNANENDRA LAL BHADURI *and* KRISHNA CHANDRA GHOSE.

(*Communicated by Dr. S. L. Hora.*)

INTRODUCTION.

No vein appears to be more susceptible to variation in the common Indian toad *Bufo melanostictus* than the dorso-lumbar vein, and probably this is also true of other species of *Bufo*. In the study of the venous system of frogs and toads in the Practical Classes we pay little attention to this vein, nevertheless its importance cannot be ignored in a comparative study, especially of the two common genera *Rana* and *Bufo*. No doubt the origin and formation of the dorso-lumbar veins show a great deal of variation in all frogs and toads, more specially in the latter (*vide infra*). The present note, however, mainly concerns the study of variations in the number of the dorso-lumbar veins that directly open into the renal-portal vein (Jacobson's vein) in *B. melanostictus*.

The numerical variation in the dorso-lumbar veins has been reported by Al-Hussaini (1939) in the two species of Egyptian toads, *B. regularis* and *B. viridis*. He states that 2—4 dorso-lumbar veins join the renal-portals either singly or in pairs. Starks and Howard (1929) note that there are two or more dorso-lumbar veins in the American toad *B. americanus*. In view of the great variability in the dorso-lumbar veins in *Bufo*, both in disposition and in number on each side, an attempt has been made to determine what is the most commonly occurring number in *B. melanostictus*, which is taught as a Salientian type in some Indian Universities.

ACKNOWLEDGMENT.

We are indebted to Rai Bahadur Dr. S. L. Hora, D.Sc., F.A.S.B., F.N.I., Director of Fisheries, Bengal, for going through the manuscript. We also offer our sincere thanks to our colleague Dr. S. P. Rai Chaudhuri for his suggestions in the preparation of these notes.

MATERIAL AND METHODS.

For this study we dissected an equal number of male and female toads (*B. melanostictus*), totalling seventy-six specimens collected in and about Calcutta. A topographic examination of

the posterior veins in fresh condition has been resorted to in all the specimens dissected by us.

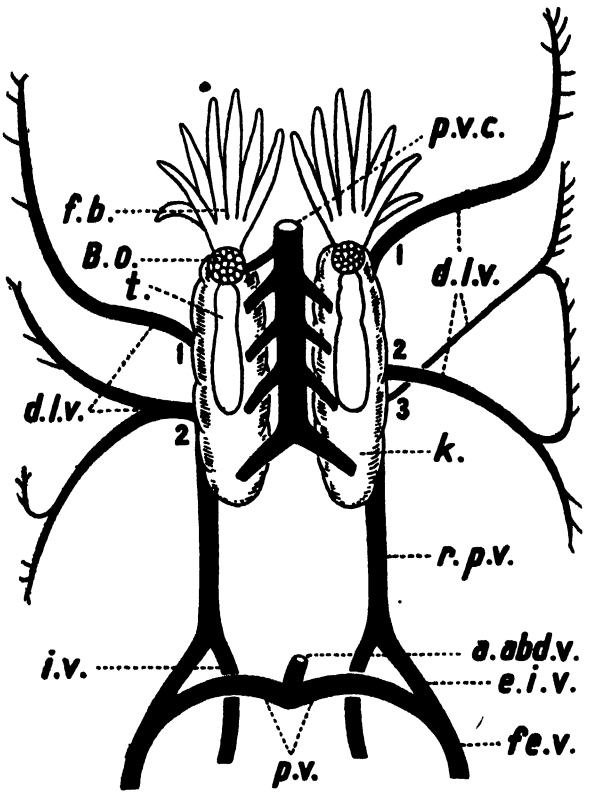
The number and disposition of the dorso-lumbar veins, not to speak of their origin and constitution, are so greatly variable that a description of the conditions in any one does not correspond to that of another. We have, therefore, given here a generalized diagram of the posterior veins of a male *B. melanostictus*, and a brief description of the course of the dorso-lumbar veins attending upon the renal-portals, which, in our opinion, will suit the purpose for which this note is prepared.

Observations.

1. The renal-portal vein (*V. iliaca communis*) [1] (Text-fig. 1, *r.p.v.*) on each side is constituted on the usual ranid pattern by the union of the external iliac vein (*e.i.v.*) and the ischiadic vein (or sciatic vein, according to some authors) (*i.v.*). It runs craniad as a free floating vein as far as the posterior level of the kidney (*k.*), whence it continues forward along the dorso-lateral outer edge of the kidney closely accompanying the Wolffian duct and gradually diminishing in size and finally disappearing at the cranial end of that organ. It (*V. Jacobsonii*) sends off numerous afferent renal vessels (*Vv. renales advehentes*) to the kidney. The portion of the renal-portal vein (*V. Jacobsonii*) applied to the kidney is better seen dorsally, and in this region it receives the dorso-lumbar veins (*d.l.v.*), and, in the case of females, a few well-marked branches from the oviduct. The dorso-lumbar veins originate on each side by the anastomosis of the small twigs directly arising from the muscles of the back and the lumbar region. After its formation each vessel courses in an undulating fashion, floating freely in the body-cavity, and ultimately opening into the renal-portal vein of the corresponding side. Two dorso-lumbars may also anastomose with each other at their points of origin (*d.l.v.*, 2 and 3, lt. side). The dorso-lumbar veins of each side open most haphazardly, one after the other, into the renal-portal, and the distance between any two vessels is subject to considerable individual variation. Their number may, however, vary from one to five on each side (*vide infra*, Table 1). In a few instances, it may be observed that two vessels instead of fusing with each other have, in fact, crossed themselves very near their separate union with the renal-portal (*d.l.v.*, 2 and 3, lt. side). It should be specially noted that the number of dorso-lumbar veins referred to in this paper is computed on the basis of the portion of the vessel which proceeds as a single trunk to connect directly with the renal-portal. This single trunk, be it noted, may be very long (*d.l.v.*, 1) or very short as in *Rana* (*d.l.v.*, 2, rt. side). In the latter case it is

[1] The nomenclature of the veins italicized within brackets is taken from Gaupp (1899).

usually formed by the union of two moderately long anterior and posterior branches (*d.l.v.*, 2, rt. side). Again, the calibre of the



Text-figure 1. Diagrammatic representation of the posterior veins of a male *Bufo melanostictus* (ventral view).

a.abd.v.—anterior abdominal vein; *B.o.*—Bidder's organ; *d.l.v.*—dorso-lumbar veins (right and left); *e.i.v.*—external iliac vein; *f.b.*—fat-body; *fe.v.*—femoral vein; *k.*—kidney; *i.v.*—ischiadic vein (sciatic vein); *p.v.*—pelvic vein; *p.v.c.*—posterior vena cava; *r.p.v.*—renal-portal vein (common iliac vein and Jacobson's vein); *t.*—testis.

different vessels constituting the dorso-lumbars also varies very considerably, some appearing as stout as the renal-portal itself and some, insignificantly slender. It is interesting to note also that the dorso-lumbars of two sides do not often correspond with one another in number (*vide infra* Table 1), position and disposition, although in some cases there may be an apparent similarity in their appearance. Curiously enough, in one instance we observed a supernumerary dorso-lumbar vein falling

into the free floating portion of the renal-portal vein (*V. iliaca communis*) behind the kidney. Attention may be drawn here that Al-Hussaini (1939) has also noted one or two such vessels occurring in some of the toads he has studied. Thus the dorso-lumbar veins provide examples of variations in their origin and constitution in relation to parts concerned, in size and direction as well as in position and number when finally joining the renal-portals.

2. With a view to showing the numerical variation of the dorso-lumbar veins, without taking other concomitant variations into consideration, we have prepared the following table. We could distinguish nine types of variations (I–IX) in all, out of 76 specimens dissected. Had we dissected more specimens of toads, we might have probably encountered other types of numerical variation as, for instance, a combination of 3 vessels on the right side with 4 on the left, or 4 on the right with 2 on the left, and so on. Of course, the number of specimens showing such supposed combinations would have been very small. Further, we have included in the table two more columns in order to check whether this variability has any bearing upon the sexes.

TABLE 1. *Showing statistical analysis of the dorso-lumbar veins in both sexes of* Bufo melanostictus.

Serial no.	No. of dorso-lumbar vein.		Male.	Female.	Both sexes.
	Rt. side.	Lt. side.			
I	1	1	1	×	1
II	1	2	×	1	1
III	2	2	14	12	26
IV	2	3	10	11	21
V	3	2	4	4	8
VI	3	3	4	6	10
VII	4	3	2	×	2
VIII	2	4	2	4	6
IX	3	5	1	×	1
Total no. of dissected specimens ..			38	38	76

From the above table it will be noticed that among the combinations of equal number of dorso-lumbars on both sides (I, III and VI), the combination of a pair on either side (III) is decidedly greater than those of the other two, *viz.*, one (I) and three (VI), of which the latter is by far greater than the former. The combination of two vessels on the right with three on the left (IV) is indeed greater than the opposite combination (V). The occurrences of other combinations (III and VII–IX) appear to be less frequent. The two combinations, 2 : 2 and 2 : 3 (III–IV), are no doubt the most common, but to these may also be added the other two combinations, 3 : 2 and 3 : 3 (V-VI) as occurring in fair numbers. Thus we accept a range of two to three vessels comprising a grouping of 4 combinations (III–VI) as the most commonly occurring number of dorso-lumbars in *B. melanostictus*. From this point of view it will be found that there are 65 such cases (32 males and 33 females) out of a total of 76 specimens dissected. The range of variation on the right side is 1–4 and on the left, 1–5.

Now, if we accept the range of variation 2–4 given by Al-Hussaini (1939) as the most commonly occurring number for the Egyptian toads *B. regularis* and *B. viridis*, it would appear to be a bit unusual when compared with that of the common Indian toad *B. melanostictus*. The range, 2 or more dorso-lumbars, given by Starks and Howard (1929) for the American toad *B. americanus*, calls for further clarification.

The figures under the columns 'Male' and 'Female' of the above table will amply justify the conclusion that there is no correlation between the sex and the numerical variation in the dorso-lumbars, since they occur in almost equal proportion in both sexes under each type of variation.

Discussion.

It will not be out of place here to review briefly the distribution of the dorso-lumbar veins in other species of Salientia, since a comparison especially between *Rana* and *Bufo* is both interesting and profitable. References to many textbooks dealing with the anatomy of frogs [1] (different species of *Rana*) will make it at once evident that whatever may be the origin and formation of the dorso-lumbar veins, it is only a single trunk that remains in coalescence with the renal-portal (*V. Jacobsonii*) on each side. But, unfortunately, this is not so in reality. For, in Gaupp's (1899, p. 420) standard work on the anatomy of *Rana esculenta* we find the following statement: 'Sehr häufig, ja vielleicht immer, münden ein oder einige der Zuflüsse der *V. dorso-lumbalis* selbständig in die *V. Jacobsonii* ein.' A more

[1] Being too well-known, they are not mentioned in the reference list.

or less similar corroborative statement will also be found in Haslam's (1889, p. 248) translation of Ecker's *Anatomie des Frosches*. It may only be noted in passing that the range of numerical variation is not definitely stated either by Gaupp or Haslam. However, the interest of these variations lies in their relation to the mode of origin of the dorso-lumbars as revealed in the development of the renal-portal system, and this has been elaborately treated by Gaupp (*op. cit.*, pp. 421-423). A brief account of the developmental history, pertinent to our point at issue, may be introduced here in order to throw light on the condition that obtains in the adult frog. Gaupp (*op. cit.*, p. 422) states: '. . . Die als *Vv. advehentes* bezeichneten lateralen Abschnitte der Wirbelvenen verbinden sich unter einander am lateralen Nierenrande durch eine Längsanastomose: Jacobson'sche Vene, die sich auch mit der *V. iliaca* in Verbindung setzt. Dadurch werden auch diese lateralen Abschnitte der Wirbelvenen wieder in zwei Hälften zerlegt: in je eine mediale (*V. advehens* im engeren Sinne) und eine laterale, die frei an den lateralen Nierenrand herantritt. Von den letzteren gehen später eine Anzahl zu Grunde, so dass beim erwachsenen Thiere nur eine (*V. dorso-lumbalis*), hin und wieder auch noch eine zweite oder mehr übrig bleiben. Ursprünglich sind also *Vv. dorso-lumbales* (hintere Wirbelvenen) in grösserer Anzahl vorhanden gewesen.' From the foregoing account it is clear that the evolutionary tendency in these embryonic vessels ('hintere Wirbelvenen') is to concentrate them on each side into one or a small number of vessels which may be described as the dorso-lumbars. This is well depicted in *Rana* in its transformation into the adult condition. Usually there is a reduction to one dorso-lumbar on each side, and this may probably be held as the most commonly occurring number in *Rana*. Occurrence of more dorso-lumbars than one in *Rana* should, therefore, be viewed as a clear indication of the persistence of embryonic condition.

Bhaduri (1938), in recording an abnormal renal-portal in the American bull-frog *R. catesbeiana*, has shown two dorso-lumbars on either side. It is not known whether this is a constant feature or not in that species. As a result of studies of a large number of specimens of the Indian bull-frog *R. tigrina*, Mathur and Sharma (1938) recorded only three cases having two dorso-lumbars instead of one. They point out that whenever this abnormality occurs, it is found on one side only, and that it has no bearing on the sex and the size of the animals. Briefly commenting upon a few cases only, O'Donoghue (1931) seems to have paid no particular attention to the numerical variability of the dorso-lumbars, although he has recorded and compiled a large number of abnormal renal-portals in the frogs.

Marriner (1905), in describing the venous system of the Australian tree-frog *Hyla aurea* has described a single dorso-lumbar vein (erroneously designed by him as 'lumbar vein')

on either side, and noted its variation in size only. In addition to this vein he calls attention to the fact that the renal-portal vein also receives another vein—'ileo-lumbar' (*sic*) draining blood from the dorsal body-wall. An examination of the figure (Pl. XLV, fig. 2) reveals, however, that this vessel joins the external iliac vein. It may be pointed out in passing that Gaupp's (1899, p. 419) *R. iliolumbalis* is the anterior branch of the dorso-lumbar vein, whereas the veins which join the external iliac vein are, according to him (*op. cit.*, p. 493), *V. cutanea femoris anterior lateralis* and *V. abdominalis lateralis postrema*. However, we may conclude that there is usually one dorso-lumbar trunk on either side in *H. aurea*.

The occurrence of more dorso-lumbars than one has been recorded in *Xenopus* by Gilchrist and von Bonde (1922) and Grobbelaar (1924 *a* and *b*). Gilchrist and von Bonde, in dealing with a comparative anatomy of *Xenopus* and *Rana*, have shown in figures only (p. 70, fig. 20) that there are three dorso-lumbars in the former as against one in the latter, without noting this fact in the text. Grobbelaar has confirmed the above observation in a figure (1924 *a*, p. 395, fig. 2) as also in the text (1924 *b*, p. 163), naming the three dorso-lumbars,—anterior, median and posterior. It is not clear whether these veins show any numerical variation as in *Rana* or *Bufo*. But from Grobbelaar's exposition it may be held that a combination of three dorso-lumbars on either side is normally constituted, and therefore a constant feature in *Xenopus*, and in this respect it can be regarded as being less specialized than any of the genera (*Rana*, *Hyla* and *Bufo*) mentioned above.

The fact that the dorso-lumbar veins vary markedly in different individuals of *Bufo* would indicate that their value is slight, and that the utility of circulation is not greatly affected either by reduction or by retention of several embryonic vessels. Their retention (which would mean an embryonic condition) and reduction (which would indicate specialization) both can be readily explained in the light of the ontogeny as given by Gaupp (1899).

The most interesting point that emerges from the above discussion is that there is a tendency of reduction of the several embryonic vessels ('hintere Wirbelvenen') to one dorso-lumbar trunk as in *Rana* and *Hyla*, and to three as in *Xenopus*, while in *Bufo* (particularly in *B. melanostictus*) we find by statistical analysis that the persisting vessels are somewhat unstable, and they vary from two to three vessels. This may indicate that *Rana* and *Hyla* are more specialized than *Xenopus* and *Bufo*, at least in this feature. But, whatever may be our interpretation of the nature of specialization of the dorso-lumbar veins, alone it does not seem to afford at present sufficient evidence for attaching any phylogenetic value to this feature. We think that the phenomenon can be discussed more intelligently only after an adequate

study of the dorso-lumbar veins of the outstanding genera and species of Salientia.

SUMMARY.

(1) Though the dorso-lumbar veins of *Bufo melanostictus* exhibit great variability in their number, the range, two to three vessels, is the most commonly occurring feature.

(2) A comparison of the dorso-lumbar veins of the described examples, belonging to the genera *Rana, Hyla* and *Xenopus*, with those of *Bufo* is made to indicate the lines of their apparent specialization.

(3) Evidence of the origin of numerical variability of the dorso-lumbars can be adduced from Gaupp's account of the development of the renal-portal system.

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ARTICLE No. 10.

Report on a Collection of Molluscs from Santal Parganas, Bihar.[1]

By HARISH CHANDRA RAY.

(*Communicated by Dr. Baini Prashad.*)

INTRODUCTION.

In the year 1938, Drs. H. S. Rao and H. A. Hafiz, Assistant Superintendents, Zoological Survey of India, Indian Museum, Calcutta, carried out a detailed survey of the fauna of the District of Santal Parganas, Bihar. Their collections are from Godda, Dumka, Pakaur, Deoghar and Rajmahal Subdivisions. The mollusca collection of both land and freshwater contains representatives of the families Achatinidae, Cyclophoridae, Zonitidae, Amnicolidae, Corbiculidae, Lymnaeidae, Melaniidae, Pilidae, Planorbidae, Viviparidae and Unionidae.

Seventeen genera and twenty-seven species are represented in the collection. The most interesting find is that of a young shell of land snail from the scrub jungle on the slope of Phuljori hills, about 20 miles from Dumka in Deoghar Subdivision. It is the type of the 'large depressed variety' of *Ariophanta* (*Ariophanta*) *interrupta* (Benson) recorded by Blanford and Godwin-Austen from Pareshnath.

In the systematic grouping of the species and varieties I have followed Kennard and Woodward[2] and Pilsbry and Bequaert.[3]

The examination of specimens has brought out certain interesting facts connected with the geographical distribution of a few species and varieties hitherto unknown from the area.

To Dr. Baini Prashad, Director, Zoological Survey of India, I have to offer my grateful thanks for kindly granting me permission to work out this interesting collection and also for his unfailing help and suggestions.

[1] Published by permission of the Director, Zoological Survey of India.

[2] Kennard, A. S. and Woodward, B. B.—Synonymy of the British Non-Marine Mollusca, pp. xi–xxiv (1926).

[3] Pilsbry, H. A. and Bequaert, J.—*Bull. Amer. Mus. Nat. Hist.*, XL, Art. I, p. 30 (1919); LIII, Art. II, pp. 69–602 (1927).

Order: PULMONATA.
Family: LYMNAEIDAE.
Genus: **Lymnaea** Lamarck, 1799.
Subgenus: **Pseudosuccinea** Baker, 1908.

Lymnaea acuminata f. typica Lamarck.

1925. *Limnaea acuminata* f. *typica*, Annandale and Rao, *Rec. Ind. Mus.*, XXVII, pp. 180, 181, figs. III and VI.
1937. *Lymnaea acuminata* f. *typica*, Prashad, *Rec. Ind. Mus.*, XXXIX, p. 278.

Two spirit specimens of this form were collected from: water round Bhanji—1 specimen (24-ii-38); a large jheel near Taljhari—1 specimen (19-ii-38).

This form has previously been recorded from the United Provinces, Central Provinces, Bengal, Bihar and Assam.

Lymnaea luteola f. typica Lamarck.

1841. *Limnaea luteola*, Delessert, *Rec. Coq. de Lamarck*, pl. xxx, figs. 5A and 5B.
1925. *Limnaea luteola* f. *typica*, Annandale and Rao, *Rec. Ind. Mus.*, XXVII, p. 184, fig. IV.

This form is represented by only one spirit specimen. It has a large and fairly thick shell in which the spire is broad and short and the suture more oblique.

This form is much more widely distributed in the Indian Empire than the typical *L. acuminata*. The specimen in the present collection was collected from a weedy pool on way to Gajeshwar near Burhait in Rajmahal Subdivision on 27-ii-38.

Lymnaea luteola f. australis Annandale and Rao.

1925. *Limnaea luteola* f. *australis*, Annandale and Rao, *Rec. Ind. Mus.*, XXVII, pp. 184, 185, fig. IV.
1929. *Limnaea luteola* f. *australis*, Rao, *Rec. Ind. Mus.*, XXXI, p. 295.

This form is represented in the collection by a series of specimens. The spire of the shell appears to be much narrower and more elongate and the suture more impressed and sinuous than in the forma typica.

Specimens were collected from: a large jheel near Taljhari—8 specimens (19-ii-38); a weedy pool on way to Gajeshwar near Burhait—19 specimens (27-ii-38); a spring locally known as Kusma jharna—2 specimens (1-iii-38); small pools of water in sand of dry bed of Sunderpahari stream—many specimens (6-iii-38); Horinduba jharna—3 specimens (27-x-38); a stream near Mosanjor Dak Bungalow—1 specimen (2-xii-38).

Lymnaea luteola f. ovalis Gray.

1820. *Limnaea ovalis*, Gray, *in Sowerby's Gen. of Shells*, Pt. VII, *Limnaea*, fig. 4.
1925. *Limnaea luteola* f. *ovalis*, Annandale and Rao, *Rec. Ind. Mus.*, XXVII, p. 184, figs. IV and VI.
1937. *Lymnaea luteola* f. *ovalis*, Prashad, *Rec. Ind. Mus.*, XXXIX, p. 278.

The seven specimens in the present collection agree closely with the descriptions given by Annandale and Rao in having the body-whorls much inflated, spire short but acuminate and the outer lip curved.

Specimens of this form were collected from: a stream originating from a spring near Boarijore—5 specimens (24-ii-38); a weedy pool on way to Gajeshwar near Burhait—1 specimen (27-ii-38); a pond near Pakaur Dak Bungalow—1 specimen (27-x-38).

Family: PLANORBIDAE.

Genus: **Gyraulus** Charpentier, 1837.

Gyraulus convexiusculus (Hutton).

1849. *Planorbis convexiusculus*, Hutton, *Journ. As. Soc. Bengal*, XVIII, Pt. II, p. 657.
1919. *Gyraulus convexiusculus*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, pp. 52–54, figs. 7B, 8B.
1934. *Gyraulus convexiusculus*, Rensch, *Archiv f. Hydrobiol. Suppl.*, XIII, pp. 209–211.
1939. *Anisus* (*Gyraulus*) *convexiusculus*, Bequaert and Clench, *Phil. Journ. Sci.*, LXIX, p. 12, figs. 4–6.

Gyraulus convexiusculus is the commonest of all the Indian species of the genus. The shells of this species vary greatly in the contour of the body-whorl, which may be completely rounded off or more or less carinate, and in the shape of the aperture.

Annandale and Prashad sum up the geographical distribution of the species as extending from 'Lower Mesopotamia through Eastern Persia, Afghanistan and Northern India to Burma, French Indo-China, China, Japan and the Malay Peninsula'.

Specimens were collected from: a large jheel near Taljhari—many specimens (19-ii-38); rivers between Bario and Bhanji—1 specimen (24-ii-38); a stream originating from a spring near Boarijore—3 specimens (24-ii-38); pools below Motijharna falls near Maharajpur Railway Station—12 specimens (20-iii-38); a rocky hill stream near Amrapara—1 specimen (14-xi-38); a stream near Mosanjor Dak Bungalow—1 specimen (2-xii-38).

Genus: **Indoplanorbis** Annandale and Prashad, 1921.

Indoplanorbis exustus (Deshayes).

1834. *Planorbis exustus*, Deshayes, *Voy. Belang. Ind. Orient. Zool.*, p. 417, pl. i, figs. 11–13.
1921. *Planorbis* (*Planorbis*) *exustus*, Germain, *Rec. Ind. Mus.*, XXI, p. 26, pl. i, figs. 4–9, pl. iv, figs. 11, 17, 18.
1921. *Indoplanorbis exustus*, Annandale and Prashad, *Rec. Ind. Mus.*, XXII, pp. 580–582.

This is the commonest of the large Planorbids of the Indian waters. It is widely distributed in the plains of India and Burma and has also been recorded from Siam, Malay Peninsula, French Indo-China and Sumatra.

Specimens of this species were collected from: water round Bhanji—3 specimens (24-ii-38); a stream originating from a spring near Boarijore—2 specimens (24-ii-38); a pond near Pakaur Dak Bungalow—4 specimens (24-x-38); Horinduba jharna—4 specimens (27-x-38); a pond in Majurkola village near Kotalpukur Railway Station—2 specimens (29-x-38); a rocky hill stream near Amrapara—1 specimen (14-xi-38); a tributary of River Triban near Rajapokhar—1 specimen (28-xi-38).

Family: ACHATINIDAE.

Genus: **Achatina** Lamarck, 1799.

Subgenus: **Achatina** Swainson, 1840.

Achatina fulica (Férussac).

1821. *Helix* (*Cochlitoma*) *fulica*, Férussac, *Tabl. Syst. Anim. Moll.*, p. 53; *Hist. Nat. Moll.*, pl. cxxiv*a*, fig. 1, pl. cxxv, figs. 3–5.
1880. *Achatina fulica*, Mobius, *Reise nach Mauritius Moll.*, pp. 197, 198.
1914. *Achatina fulica*, Gude, *Faun. Brit. Ind. Land Moll.*, II, p. 340.
1939. *Achatina fulica*, Adam et Leloup, *Mem. Mus. Roy. Hist. Nat. Belg.*, II, Fasc. 20, p. 16.

The most important conchological feature which distinguishes this species from *panthera* and its allies is the whitish columellar region.

Achatina fulica is a gigantic land snail, and only species of the genus *Achatina* found in India. It is an East African species but has been introduced into Mauritius, Seychelles, Bourbon, British India, Ceylon, Malaya, China, North Borneo, Sumatra and Java through human agency.

The introduction of this animal into India from its original home, Madagascar, dates back to 1847, when Benson brought some living snails from Mauritius to Calcutta where they became naturalized.

It is interesting to record the occurrence of the species in the Santal Parganas, Bihar, where it has certainly migrated from the neighbouring districts of Bengal.

Two specimens of this species were collected from the rocky and sandy bed of the River Triban on 13th and 19th Nov., 1938, respectively.

Family : ZONITIDAE.

Genus : **Macrochlamys** Benson, 1832.

Subgenus : **Macrochlamys** S. S.

Macrochlamys pedina (Benson).

1865. *Helix pedina*, Benson, *Ann. & Mag. Nat. Hist.* (3), XV, pp. 13, 14.

1897. *Nanina pedina*, Peile, *Journ. Bomb. Nat. Hist. Soc.*, XI, p. 133.

1900. *Nanina (Xesta) pedina*, Kobelt, *in Martini and Chemnitz's Syst. Conch.—Cab.*, I, Abth. 12, Pt. V, p. 980, pl. cclv, figs. 4, 5; p. 1021, pl. cclxiii, fig. 2.

1908. *Macrochlamys pedina*, Blanford and Godwin-Austen, *Faun. Brit. Ind. Moll.*, pp. 132, 133, figs. 50, 51.

There is only one dry bleached shell in the collection which agrees with the description of the species by Blanford and Godwin-Austen.

Macrochlamys pedina is a common garden snail of Bombay. It has also been recorded from Ahmednugger, Kachh and South Canara, Bengal, Mirzapur and Philippine Islands.

The single shell in the collection was found at Sakrigali Ghat in Rajmahal Subdivision on 21-iii-38.

Macrochlamys petrosa (Hutton).

1834. *Helix petrosa*, Hutton, *Journ. As. Soc. Bengal*, III, p. 83.

1883. *Macrochlamys petrosa*, Godwin-Austen, *Moll. Ind.*, I, Pt. IV, p. 99, pl. xix, fig. 1-1*a* (animal); pl. xxi, fig. 2 (sculpture); pl. xxii, fig. 1 (shell).

1908. *Macrochlamys petrosa*, Blanford and Godwin-Austen, *Faun. Brit. Ind. Moll.*, pp. 96, 97.

1929. *Macrochlamys petrosa*, Thiele, *Handb. der Syst. Weichtierk.*, I, p. 628.

Hutton, and not Gray, first described the shell and the animal of this species under the name *Helix petrosa*. His speci-

mens were collected at Tara, in the low range of the rocky hills near Mirzapur, in the month of August, 1832.

Blanford and Godwin-Austen give the geographical range of this species as 'The country south of the Gangetic plain from Rájmahál to Bundelkhand, especially on hills at Rájmahál, Patharghatta, near Mirzapur, etc.'.

In the collection this species is represented by a single dry shell which was collected from the Gukulpur River near Kunjbona Dak Bungalow in Pakaur Subdivision on 1-xi-38.

Genus: **Ariophanta** Desmoulins, 1833.

Subgenus: **Ariophanta** S. S.

Ariophanta interrupta (Benson).

1832–34. *Helix interrupta*, Benson, *Zool. Journ.*, V, p. 461.
1883. *Ariophanta interrupta*, Godwin-Austen, *Moll. Ind.*, I, Pt. IV, p. 134, pl. xxxiv, figs. 2, 2*a*.
1886. *Nanina* (*Ariophanta*) *himalayana*, Tryon, *Man. Conch.* (2), II, p. 17, pl. ii, figs. 17, 18.
1905. *Nanina* (*Ariophanta*) *interrupta*, Kobelt, *in Martini and Chemnitz's Syst. Conch.—Cab.*, I, Abth. 12, Pt. IV, p. 1165, pl. ccxc, figs. 1–3.
1908. *Ariophanta* (*Ariophanta*) *interrupta*, Blanford and Godwin-Austen, *Faun. Brit. Ind. Moll.*, p. 31.

A young shell in the collection appears to be of the type of the 'large depressed variety' of *Ariophanta* (*Ariophanta*) *interrupta* (Benson) recorded by Blanford and Godwin-Austen from Pareshnath.

I give below a detailed description of the shell: shell sinistral, thin, perforate, pellucid, much depressed, light brownish horny, whorls 4½, regularly increasing in size, the last one descending slightly, comparatively broader than the penultimate, sharply keeled at the periphery and slightly swollen below, 1st and 2nd whorls finely obliquely striated above and ornamented with fine longitudinal granules arranged in close spiral lines, 3rd and 4th whorls plicately striated and decussated with spiral lines, ventrally radiately striated with indistinct spiral lines, spire flatly conoidal, apex obtuse, suture only slightly impressed, aperture diagonal, ovally lunate, upper lid thin, slightly arcuate and angulate at the keel of the last whorl, columellar lip short, almost vertical, expanded at the base and partly reflected over the perforation.

Measurements (*in millimetres*).

Height of the shell	.. 10 mm.
Diameter of the shell ..	.. 17 mm.
Length of the aperture ..	.. 10 mm.
Breadth of the aperture ..	.. 9·5 mm.

Blanford and Godwin-Austen sum up the geographical range of this species as 'Bengal, Bihar, Orissa, Ganjam, Golconda Hills, Vizagapatam. Common to Calcutta [and extends to Jessore]'.

The single shell in the collection was found in a scrub jungle on the slope of Phuljori hills, about 20 miles from Dumka in Deoghar Subdivision on 1-xii-38.

Family: CYCLOPHORIDAE.

Genus: **Cyclophorus** Montfort, 1810.

Subgenus: **Litostylus** Kobelt and Möllendorff, 1897.

Cyclophorus pyrotrema Benson.

1835. *Cyclostoma involvulus*, Benson, *Zool. Journ.*, V, p. 462.
1854. *Cyclophorus pyrotrema*, Benson, *Ann. & Mag. Nat. Hist.* (2), XIV, p. 412.
1908. *Cyclophorus* (*Litostylus*) *pyrotrema*, Kobelt, *in Martini and Chemnitz's Syst. Conch.—Cab.*, I, Abth. 19, Pt. I, p. 665, pl. xcvii, fig. 3.
1921. *Cyclophorus* (*Litostylus*) *pyrotrema*, Gude, *Faun. Brit. Ind. Moll.*, III, pp. 54, 55.

A beautiful shell of this species in the collection consists of five whorls and has a conical spire. The whorls are slopingly convex; the suture is zig-zagged with streaks of burnt chestnut, the aperture is not regularly circular, the peristome is unspotted, and the lip of a bright vermilion-orange colour.

The single shell in the collection was collected at Sakrigali Ghat on 21-iii-38.

Family: AMNICOLIDAE.

Subfamily: *BULIMININAE*.

Genus: **Bulimus** Scopoli, 1777.

Subgenus: **Digoniostoma** Annandale, 1920.

Bulimus pulchellus (Benson).

1836. *Paludina pulchella*, Benson, *Journ. As. Soc. Bengal*, V, p. 746.
1921. *Digoniostoma pulchella*, Annandale, *Rec. Ind. Mus.*, XXII, p. 541.
1923. *Amnicola* (*Alocinma*) *pulchella*, Annandale and Rao, *Rec. Ind. Mus.*, XXV, p. 395.
1940. *Digoniostoma pulchella*, Laidlaw, *Bull. Raff. Mus. Singapore*, XVI, p. 133.

The large series of specimens in the collection before me do not differ in any respect from the typical shells of the species in the Indian Museum Collection.

It is common in parts of Assam and the adjoining districts of Burma and has also been recorded from Bengal, Bihar, Orissa, Madras, Bombay, Coconada in South India and the United Provinces.

The species was collected from: water round Bhanji—1 specimen (24-ii-38); a stream originating from a spring near Boarijore—5 specimens (24-ii-38); a weedy pool on way to Gajeshwar near Burhait—10 specimens (27-ii-38); a spring locally known as Kusma jharna—2 specimens (1-iii-38); a rocky hill stream near Amrapara—5 specimens (14-xi-38).

Subgenus: **Alocinma** Annandale and Prashad, 1919.

Bulimus orculus (Frauenfeld).

1862. *Bithynia orcula* (Benson MS.), Frauenfeld, *Verhandl. d. K.K. Zool.-bot. Ges. Wien*, XII, pp. 1154, 1155.
1919. *Amnicola* (*Alocinma*) *orcula*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, p. 24.
1923. *Amnicola* (*Alocinma*) *orcula*, Annandale and Rao, *Rec. Ind. Mus.*, XXV, p. 601.

For a detailed account of this species reference may be made to the paper by Annandale and Prashad cited above. This species is widely distributed in Bengal, Bihar, Orissa, Assam, and the United Provinces and Delhi. Its range, however, does not seem to extend in the south-easterly direction beyond Manipur.

Specimens of this species were collected from a jheel near Taljhari on 19-ii-38.

Family: PILIDAE.

Genus: **Pila** Röding, 1798.

Pila conica var. **compacta** (Reeve).

1856. *Ampullaria compacta*, Reeve, *Conch. Icon.*, X, pl. xiv, fig. 2; pl. xv, fig. 71.
1925. *Pila conica* var. *compacta*, Prashad, *Mem. Ind. Mus.*, VIII, p. 80, pl. v, figs. 9, 10.
1928. *Pila conica* f. *compacta*, Rao, *Rec. Ind. Mus.*, XXX, p. 425.

This form is represented by seven dry shells in which the colour is dark olive-brown; narrow spiral bands are also present in two shells.

It is found in Burma and also in the Malay Peninsula.

The shells were collected from: near the River Torai—5 specimens (23-x-38); sandy bed of the River Bhamri near Dumka Dak Bungalow—2 specimens (5-xii-38).

Pila virens (Lamarck).

1822. *Ampullaria virens*, Lamarck, *Hist. Nat. Anim. Sans Verteb.*, VI (2), p. 179.
1925. *Ampullaria virens*, Alderson, *Studies in Ampullaria*, pp. 72–74, pl. xv, figs. 3, 4; pl. xvi, fig. 1.
1925. *Pila virens*, Prashad, *Mem. Ind. Mus.*, VIII, pp. 75, 76, pl. xiv, figs. 1–3.

Of the five young specimens of this species in the collection three have a smooth shell slightly tinted with yellow, while the other two are dark-brown and banded externally with narrow brownish spiral lines and vertically striped. There is also a conspicuous longitudinal chocolate-brown mark in the columellar region.

Regarding the distribution of the species, Prashad writes, 'This species has a very wide range in Peninsular India and extends through Orissa and Bengal to Assam. In the south I have seen specimens from below Pondicherry and it probably extends further south'.

Specimens in the collection were collected from: Barhabad nullah near Pachathol village—1 specimen (27-x-38); a nullah near Kotalpukur Railway Station—2 specimens (29-x-38); a rocky hill stream near Amrapara—2 specimens (14-xi-38).

Family: MELANIIDAE.

Genus: **Melanoides** Olivier, 1807.

Subgenus: **Melanoides** S. S.

Melanoides tuberculatus (Müller).

1774. *Nerita tuberculata*, Müller, *Verm. Terr. Fluv. Hist.*, II, p. 191.
1919. *Melanoides* (*Plotia*) *tuberculata*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, pp. 31, 32, pl. iv, fig. 1.
1925. *Melanoides tuberculatus*, Annandale and Rao, *Rec. Ind. Mus.*, XXVII, p. 118.

The shells of this species vary greatly in shape, size and sculpture.

This is one of the commonest of the non-marine Gastropod Molluscs and its wide range, as pointed out by Annandale and Prashad, extends from the Mediterranean to Australia and China.

Seventeen specimens of this species were collected from: a pool of water near Taljhari Dak Bungalow—6 specimens (19-ii-38); small pools in sand of dry bed of Sunderpahari stream—7 specimens (6-iii-38); Guhundra nullah near Litipara—2 specimens (3-xi-38); a river near Litipara Dak Bungalow—2 specimens (8-xii-38).

Melanoides flavidus (Nevill) Annandale and Prashad.

1884. *Melania (Striatella) tuberculata* var. *flavida*, Nevill, *Hand List Moll. Ind. Mus.*, II, p. 244.
1919. *Melanoides pyramis* var. *flavida*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, pp. 29, 30, 34–36, figs. 3, 4; pl. iii, fig. 6; pl. iv, fig. 6.
1923. *Melanoides flavidus*, Annandale and Rao, *Rec. Ind. Mus.*, XXV, pp. 395, 396.

I follow Annandale and Rao in considering this form as a distinct species rather than a variety or subvariety of *M. tuberculatus* or *M. pyramis*.

Melanoides flavidus is represented in the collection by a series of specimens which exhibit the distinctive characters of the species; these are: the more expanded aperture, the absence of longitudinal ribs on the surface, the presence of an indistinct smooth ridge running below the suture and the presence of a distinct notch at the lower margin of the operculum.

The species is widely distributed in India, Burma, South Baluchistan, Persia, Iraq and Lower Mesopotamia.

A large number of specimens of this species were collected from: muddy parts of Morel River near Bario—18 specimens (24-iii-38); rivers between Bario and Bhanji—1 specimen (24-ii-38); a tributary stream of the Gumani River near Kusma—9 specimens (28-ii-38); Ronbyhad stream—3 specimens (1-xi-38); a rocky hill stream at the foot of the eastern slope of Rajmahal Hills near Litipara—6 specimens (3-xi-38); Jhobbo stream—2 specimens (4-xi-38); Mondhuboun stream—9 specimens (5-xi-38).

Melanoides pyramis (Hutton).

1836. *Melania pyramis*, Hutton, *Journ. As. Soc. Bengal*, V, p. 782.
1915. *Tiara (Striatella) pyramis*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, pp. 20, 21.
1919. *Melanoides pyramis*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, pp. 28–30, 32, pl. iv, fig. 3.

The species is widely distributed in the Gangetic provinces of India and also occurs in Afghanistan and Baluchistan. Hutton limits the geographical range of the species westward to Quetta beyond which he failed to find any trace of it.

The species was collected from: muddy parts of Morel River near Bario—4 specimens (24-iii-38); a tributary stream of the Gumani River near Kusma—1 specimen (28-ii-38); a sandy bed of tributary of River Triban near Rajapokhar—1 specimen (28-xi-38); a stream near Mosanjor Dak Bungalow—2 specimens (2-xii-38).

Melanoides pyramis var. **leopardina** Annandale and Prashad.

1876. *Melania pyramis* and var. *adspersa*, Hanley et Theobald (nec Troschel), *Conch. Ind.*, pp. 44, 45, pl. cx, figs. 1, 2, 4.

1919. *Melanoides pyramis* var. *leopardina*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, p. 33, pl. iv, fig. 4.

For a long time this form was confounded with the forma *typica* of the species, and it was not until 1919, that Annandale and Prashad on the basis of certain important anatomical features described it as a new variety.

According to Annandale and Prashad 'It is not uncommon, though apparently somewhat sporadic, in the Indo-Gangetic plain and Peninsular India'.

Twenty specimens of this form were collected from: muddy parts of Morel River near Bario—3 specimens (24-iii-38); a rocky hill stream at the foot of the eastern slope of Rajmahal Hills near Litipara—1 specimen (3-xi-38); a sluggish stream on way to Dumarchir from Amrapara—8 specimens (13-xi-38); River Ikri near Dumarchir—8 specimens (15-xi-38).

Subgenus: **Plotia** Röding, 1798.

Melanoides scabra (Müller).

1774. *Buccinum scabrum*, Müller, *Verm. Terr. Fluv. Hist.*, II, p. 136.

1934. *Melania* (*Plotia*) *scabra*, Rensch, *Archiv f. Hydrobiol. Suppl.*, XIII, pp. 234–239.

1938. *Melania* (*Plotia*) *scabra*, Adam et Leloup, *Mem. Mus. Roy. Hist. Nat. Belg.*, II, Fasc. 19, pp. 89, 90, pl. v, fig. 6.

The large series of specimens in the collection agree in all essential shell-characters with the typical shells in the Indian Museum Collection.

Melanoides scabra has a wide range of distribution in India, Burma, Ceylon, Andamans, Mauritius and Seychelles.

Localities representing the specimens in the collection are: Rivers between Bario and Bhanji—2 specimens (24-ii-38); sandy parts of the Gumani River near Kusma—6 specimens (28-ii-38); Dumra River near Simlong—1 specimen (3-iii-38); muddy parts of Morel River near Bario—1 specimen (24-iii-38); a rocky hill stream at the foot of the eastern slope of Rajmahal Hills near Litipara—2 specimens (3-xi-38); Karla River—5 specimens (4-xi-38); Mondhuboun stream—1 specimen (5-xi-38); a river near Litipara Dak Bungalow—8 specimens (8-xi-38).

Subgenus: **Tarebia** H. & A. Adams, 1859.

Melanoides lineatus (Gray).

1828. *Helix lineata*, Gray, *in Wood's Index Testaceol. Suppl.*, p. 24, pl. viii, fig. 68.
1915. *Tiara (Tarebia) lineata*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 34.
1938. *Melania (Tarebia) granifera lineata*, Adam et Leloup, *Mem. Mus. Roy. Hist. Nat. Belg.*, II, Fasc. 19, pp. 90, 91, pl. v, fig. 7.

The distribution of this species is almost the same as in *M. scabra*, and it seems always to occur in close association with the latter.

Specimens of this species were collected from: Rivers between Bario and Bhanji—3 specimens (24-ii-38); muddy parts of Morel River near Bario—4 specimens (24-iii-38); Jhobbo stream—11 specimens (4-xi-38); Karla River—2 specimens (4-xi-38); a river near Litipara Dak Bungalow—13 specimens (8-xi-38); a tributary stream of the Gumani River near Kusma—6 specimens (28-ii-38).

Genus: **Acrostoma** Brot, 1874.

Acrostoma variabilis (Benson).

1836. *Melania vaiabilis*, Benson, *Journ. As. Soc. Bengal*, V, p. 746.

The great variability of the shells of this species is apparent in a number of shells before me, i.e. in some the longitudinal ribs are quite prominent, while in others these are rudimentary or entirely absent.

This species was originally recorded from the Goomty River, Jaunpur, United Provinces and was later found in Arakan, Pegu, Assam and Bengal. Its range extends to Sumatra also.

Twelve spirit specimens of this species were collected from small pools below Motijharna falls near Maharajpur Railway Station on 20-iii-38.

Family: VIVIPARIDAE.

Genus: **Viviparus** Montfort, 1810.

Viviparus bengalensis f. typica (Lamarck).

1822. *Paludina bengalensis*, Lamarck, *Hist. Nat. Anim. Sans Verteb.*, VI (2), p. 174.
1921. *Vivipara bengalensis* race *bengalensis*, Annandale, *Rec. Ind. Mus.*, XXII, pp. 270, 271, pl. i, figs. 1–3.

Typical shells of this form were collected from: a large jheel near Taljhari—3 specimens (19-ii-38); a tributary stream of the Gumani River near Kusma—4 specimens (28-ii-38); a spring locally known as Kusma jharna—7 specimens (1-iii-38); near the River Torai—2 specimens (23-x-38); Horinduba jharna—1 specimen (27-x-38); a rocky hill stream at the foot of the eastern slope of Rajmahal Hills near Litipara—5 specimens (3-xi-38); Mondhuboun stream—1 specimen (5-xi-38); a rocky hill stream near Amrapara—1 specimen (14-xi-38); sandy bed of the River Bhamri near Dumka Dak Bungalow—1 specimen (5-xii-38).

Viviparus bengalensis race **doliaris** (Gould).

1843. *Paludina doliaris*, Gould, *Proc. Bost. Soc. Nat. Hist.*, I, p. 144.
1869. *Paludina digona*, Blanford, *Proc. Zool. Soc. London*, p. 445.
1907. *Vivipara doliaris* and *V. digona*, Kobelt, *in Martini and Chemnitz's Syst. Conch.—Cab.*, I, Abth. 21, Pt. II, p. 145, pl. xxix, figs. 4, 5; p. 195, pl. xxxix, figs. 8–11.
1921. *Vivipara bengalensis* race *doliaris*, Annandale, *Rec. Ind. Mus.*, XXII, pp. 273, 274, pl. i, fig. 9.
1929. *Viviparus bengalensis* race *doliaris*, Rao, *Rec. Ind. Mus.*, XXXI, p. 278.

This race is widely distributed in India and Burma, but appears to have its headquarters in the valley of the Irrawaddy. Rao says that the forma *typica* of the species which was at one time so dominant in Burma has been more or less totally replaced by the race *doliaris*.

A single shell of the type was taken from a stream near Mosanjor Dak Bungalow on 2-xii-38.

Viviparus bengalensis race **mandiensis** Kobelt.

1909. *Vivipara bengalensis* var. *mandiensis*, Kobelt, *in Martini and Chemnitz's Syst. Conch.—Cab.*, I, Abth. 21, Pt. II, p. 414, pl. lxxvii, figs. 8–10.
1921. *Vivipara bengalensis* race *mandiensis*, Annandale, *Rec. Ind. Mus.*, XXII, pp. 271, 272, pl. i, figs. 4 and 10.
1922. *Vivipara bengalensis* race *mandiensis*, Prashad, *Rec. Ind. Mus.*, XXIV, p. 17.

The three specimens in the collection agree closely with the description given by Annandale. The spire is more conical and slightly narrower than in the forma *typica*, the aperture is more projecting, and the alternation of broad and narrow spiral bands is very prominent.

Specimens were collected from a stream originating from a spring near Boarijore on 24-ii-38.

Viviparus bengalensis phase **annandalei** (Kobelt).

1908. *Vivipara annandalei*, Kobelt, *Nachr. Malak. Ges.*, LX, pp. 161, 162.

1921. *Vivipara bengalensis* phase *annandalei*, Annandale, *Rec. Ind. Mus.*, XXII, p. 276, pl. ii, figs. 5–8.

The phase *annandalei*, which Kobelt considered as 'eine kritische form', was determined by Annandale in 1921. It is represented in the collection by eight specimens which are easily recognized by the thinness and translucency of the shells. The suture in this phase is very shallow.

Specimens of this phase were collected from: a pond near Pakaur Dak Bungalow—2 specimens (24-x-38); a pond in Majurkola village—6 specimens (29-x-38).

Viviparus bengalensis phase **halophila** Kobelt.

1908. *Vivipara annandalei halophila*, Kobelt, *Nachr. Malak. Ges.*, LX, p. 162.

1921. *Vivipara bengalensis* phase *halophila*, Annandale, *Rec. Ind. Mus.*, XXII, p. 277, pl. ii, figs. 9, 10.

Three spirit specimens of this phase agree in all essential features with the description of Annandale.

The type-series was collected from the Salt Range, Punjab, and specimens were also collected from Calcutta and Burdwan in Bengal. It is interesting to record for the first time its occurrence in the District of Santal Parganas, Bihar, where it was found in the following localities: pools below Motijharna falls near Maharajpur Railway Station—1 specimen (20-iii-38); a nullah near Kotalpukur Railway Station—1 specimen (29-x-38); a pond in Majurkola village—1 specimen (29-x-38).

Viviparus dissimilis (Müller).

1774. *Nerita dissimilis*, Müller, *Verm. Terr. Fluv. Hist.*, II, p. 184.

1928. *Viviparus dissimilis*, Prashad, *Mem. Ind. Mus.*, VIII, p. 163, pl. xix, fig. 2.

1928. *Viviparus dissimilis*, Rao, *Rec. Ind. Mus.*, XXX, p. 417.

Rao in his report remarks, 'Amongst the many species of Viviparus occurring in India and Burma, *V. bengalensis* appears to be extremely variable, and perhaps next in point of variability comes *V. dissimilis*'.

Prashad in discussing the distribution of this species writes, 'Though the type-species is confined to India and Burma only,

nearly related species or forms derived from it are found in China and Japan on the one hand and in the Malay Peninsula, Siam, Cambodia, Annam and the East Indies on the other'.

Three specimens of this species were collected from: a large jheel near Taljhari—2 specimens (19-ii-38); a pond near Pakaur Dak Bungalow—1 specimen (24-x-38).

Order: EULAMELLIBRANCHIATA.

Family: CORBICULIDAE.

Genus: **Corbicula** Megerle von Mühlfeldt, 1811.

Corbicula striatella Deshayes.

1854. *Corbicula striatella, C. bengalensis* and *C. trigona*, Deshayes, *Proc. Zool. Soc. London*, XXII, p. 344.

1928. *Corbicula striatella*, Prashad, *Mem. Ind. Mus.*, IX, pp. 18–20, pl. iii, figs. 9–11.

Corbicula striatella is by far the commonest species of the genus found in India. It was originally described by Deshayes in 1854 from the collection of Hugh Cuming, who obtained the material from Pondicherry. The range of the species, as stated by Prashad, extends 'practically all over India, from Peshawar in the north to Pondicherry and lower down south in the Madras Presidency and from Sindh in the north-west to Assam; it is also found in Burma'.

Only three specimens were collected from: a tributary stream of the Gumani River near Kusma—2 specimens (28-ii-38); muddy parts of Morel River near Bario—1 specimen (24-iii-38).

Genus: **Pisidium** Pfeiffer, 1821.

Subgenus: **Neopisidium** Odhner, 1921.

Pisidium clarkeanum G. & H. Nevill.

1871. *Pisidium clarkeanum*, Nevill, *Journ. As. Soc. Bengal*, XL, Pt. II, pp. 9, 10, pl. i, figs. 4, 4*a–d*.

1925. *Pisidium clarkeanum*, Prashad, *Rec. Ind. Mus.*, XXVII, pp. 408–412, figs. 1–3; pl. vii, figs. 1, 2; pl. viii, figs. 1, 2.

1937. *Pisidium clarkeanum*, Prashad, *Rec. Ind. Mus.* XXXIX, p. 280.

1940. *Pisidium clarkeanum*, Odhner, *Nova Guinea N.S.*, IV, p. 217.

P. clarkeanum has been recorded from Bengal, Bihar, United Provinces, Bombay, Maymyo, He-Ho plain and Inlé Lake, Burma. Prashad in his report of the Yale North India Expedition records its occurrence in a tank at Ootacamund, Nilgiri Hills (alt. 7,400 ft.), S. India.

The localities representing the specimens in the collection are: small pools of water in sand of dry bed of Sundarpahari stream—1 specimen (6-iii-38); a stream originating from a spring near Boarijore—12 specimens (24-iii-38).

Family: UNIONIDAE.

Genus: **Lamellidens** Simpson, 1900.

Lamellidens corrianus (Lea).

1834. *Unio corrianus*, Lea, *Trans. Amer. Phil. Soc.* (2), V, p. 65, pl. ix, fig. 25.
1915. *Lamellidens* (*Lamellidens*) *marginalis* subsp. *corrianus*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 183.
1921. *Lamellidens corrianus*, Prashad, *Rec. Ind. Mus.*, XXII, p. 609, fig. 29.
1922. *Lamellidens corrianus*, Prashad, *Rec. Ind. Mus.*, XXIV, pp. 106, 107, pl. ii, figs. 9–11.

Prashad after a critical study of the shell-structure and the anatomy of its soft parts remarks, 'This species is not a form of *L. marginalis*, as Preston thinks, but quite distinct, for not only are the shells different but the marsupium also is formed quite differently in the two species'.

In the present collection the species is represented by only one spirit specimen which, though young, agrees in all its essential particulars with the description given by Prashad.

This is an extremely variable species and, like *L. marginalis*, has a wide distribution in India and Burma.

The single specimen was collected from a dirty pond near Katikund Dak Bungalow in Dumka Subdivision on 25-xi-38.

Genus: **Indonaia** Prashad, 1918.

Indonaia caerulea (Lea).

1834. *Unio caeruleus*, Lea, *Trans. Amer. Phil. Soc.*, IV, p. 95, pl. xiii, fig. 25.
1914. *Nodularia caerulea*, Simpson, *A Descr. Cat. Naiades*, 1, p. 978.
1922. *Indonaia caerulea*, Prashad, *Rec. Ind. Mus.*, XXIV, p. 94.
1928. *Indonaia caerulea*, Rao, *Rec. Ind. Mus.*, XXX, p. 463.

This species was originally described by Lea, in 1834, from a collection made by Mr. G. W. Blakie from the river Hooghly, Calcutta. Simpson later published a detailed description of this species.

It is extremely variable and is the commonest species of the genus *Indonaia* widely distributed throughout India and Burma.

Specimens in the collection were collected from: a tributary stream of the Gumani River near Kusma—8 specimens (28-ii-38); muddy parts of Morel River near Bario—8 specimens (28-iii-38); River Ikri near Dumarchir—2 specimens (11-xi-38); Jhobbo stream—1 specimen (14-xi-38).

Indonaia caerulea var. **gaudichaudi** (Eydoux).

1838. *Unio gaudichaudi*, Eydoux, *Mag. de Zool. Cl.*, V, p. 10, pl. cxviii, fig. 3.
1914. *Nodularia gaudichaudi*, Simpson, *A Descr. Cat. Naiades*, 1, p. 982.
1915. *Nodularia* (*Nodularia*) *caeruleus* var. *gaudichaudi*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 137.
1918. *Indonaia caerulea* var. *gaudichaudi*, Prashad, *Rec. Ind. Mus.*, XV, pp. 147, 148, figs. 2, 3.
1921. *Indonaia caerulea* var. *gaudichaudi*, Prashad, *Rec. Ind. Mus.*, XXII, p. 603.

Simpson described the conchological features of this variety, while Prashad dealt with its soft parts.

So far as is known, this variety appears to be confined to Bengal and Bihar.

The single specimen in the collection was found in a tributary stream of the Gumani River near Kusma on 28-ii-38.

Genus: **Potomida** Swainson, 1840.

1840. *Potomida*, Swainson, *A Treatise on Malacology*, p. 268.
1853. *Parreysia*, Conrad, *Proc. Acad. Nat. Sc. Phil.*, VI, p. 267.
1936. *Potomida*, Prashad, *Proc. Malac. Soc. London*, XXII, Pt. III, pp. 120, 121.

Prashad in his recent paper discussed in detail the nomenclature of this genus and concluded, 'Swainson's designated *corrugata* as the type of his new genus *Potomida*, which name must, therefore, replace *Parreysia* Conrad'.

This genus is spread throughout India, Burma, Indo-China and China.

Subgenus: **Potomida** S. S.

Potomida favidens var. **chrysis** (Benson).

1862. *Unio favidens* var. *chrysis*, Benson, *Ann. & Mag. Nat. Hist.* (3), X, p. 189.
1876. *Unio favidens* var. *chrysis*, Hanley et Theobald, *Conch. Ind.*, p. 19, pl. xli, fig. 3.
1915. *Parreysia* (*Parreysia*) *favidens* var. *chrysis*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 160.

This variety was originally described by Benson, in 1862, from the river Dojora at Kareily Ghat, near Bareilly, United Provinces, and was later recorded by Preston from Patna in Bihar.

The series of specimens in the collection were collected from: muddy parts of Morel River near Bario—19 specimens (24-ii-38); sandy parts of Gumani River near Kusma—3 specimens (28-ii-38); River Torai near Pakaur Dak Bungalow—2 specimens (23-x-38); River Ikri near Dumarchir—1 specimen (15-xi-38).

Potomida corrugata (Müller).

1774. *Mya corrugata*, Müller, *Verm. Terr. Fluv. Hist.*, II, p. 214.
1914. *Parreysia corrugata*, Simpson, *A Descr. Cat. Naiades*, I, pp. 1105–1107.
1918. *Parreyssia corrugata*, Prashad, *Rec. Ind. Mus.*, XV, pp. 145, 146, fig. 1*f*.
1936. *Potomida corrugata*, Prashad, *Proc. Malac. Soc. London*, XXII, Pt. III, pp. 120, 121.

Simpson supplements Müller's description of *P. corrugata* which is very meagre. In regard to the variability of the shells of this form he remarks, 'The shells of this group are very variable and, it seems to me, have received far too many names at the hands of the conchologists'.

A small dry shell of the species in the collection is inequilateral—a character very scarcely found in this species. The colour of the shell is grass-green, its surface zig-zagged, beaks small but prominent, and its anterior side very short and completely rounded, while the posterior side narrow and bluntly truncated.

The species is distributed throughout India, Burma and Ceylon.

The single shell was found in a pond near Pakaur Dak Bungalow on 24-x-38.

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ARTICLE No. 11.

Blood Groups of Tribes and Castes of the U.P. with special reference to the Korwas.

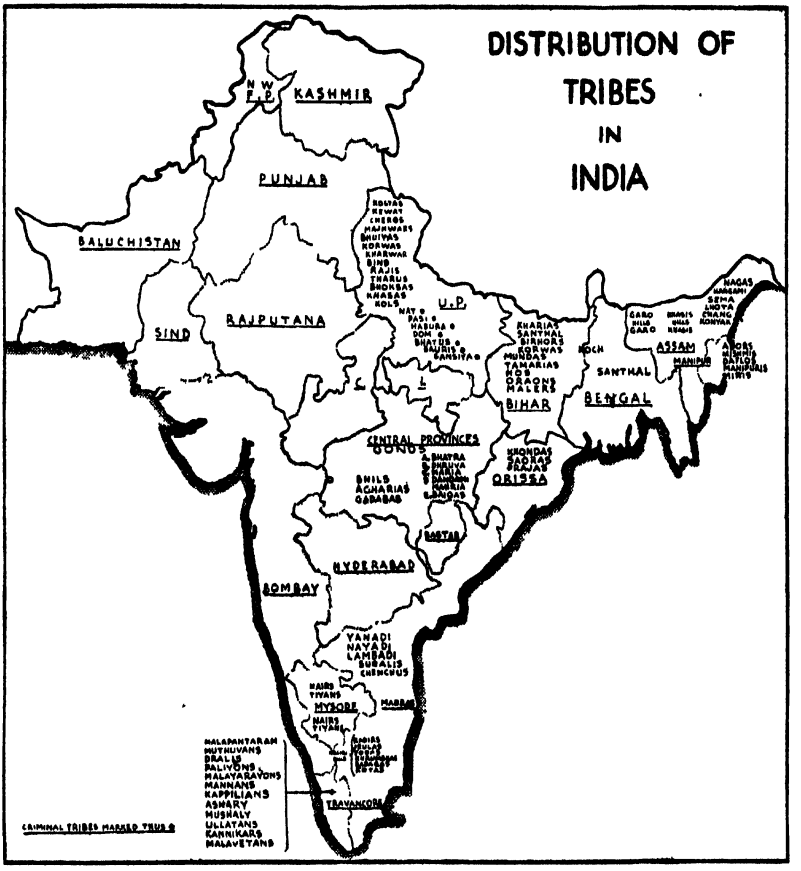
By D. N. MAJUMDAR.

In India there exist a number of tribal concentrations. In Assam, the Naga tribes inhabit compact areas. The Chotanagpur plateau is the home of the aboriginal tribes of pre-Dravidian affiliation. The Gonds are found widely scattered, but they have gravitated mostly in the Central Provinces, particularly in some of the states of the Eastern Agency. The Bhils are scattered in the Central India Agency tracts, in Gujarat and Hyderabad. Many pre-Dravidian and mixed Dravidian tribes inhabit the hilly tracts of the Madras Presidency, and the States of the South, in the Nilgiri and adjacent areas in Malabar. The main centres of tribal concentration in northern India are the Chotanagpur plateau with adjoining Indian States of Sarguja, Jashpur, Rewa, and the Mirzapur district of the U.P., also Bundelkhand and Baghelkhand, and the cis-Himalayan and submontane districts in the United Provinces.

DISTRIBUTION OF THE TRIBES.

Through centuries of contacts, migration and expulsion many of the tribes have spread to various parts of the country, and today a tribe is not always a geographical or territorial unit as it originally was. The same tribe may now be found in two or more Provinces with little racial or social affiliation in some cases, the former due to crossing with the backward castes and groups in the areas they have settled, the latter due to distance and the myth of dissociation from their traditional customs and practices and their participation in alien rites and rituals. Often tribal groups have migrated to distant factories and plantations lured by prospects of high wages, freedom from social control and for the sake of adventure. 'Fresh fields and pastures new' have also tempted tribes to leave their ancestral moorings and seek shelter in distant lands. Criminal habits and 'Crime Culture' have scattered tribal groups like the Sansiyas, Bauris, Bhatus and Karwals all over India and the same tribe has assumed different names to escape the vigilance of the police even as individuals have adopted new names, fictitious titles or ascetic garbs to escape detection. Tribal rites and rituals, traditional customs and ways of living, have been superseded by caste prescriptions or by conversion to more dynamic faiths and while a section of a tribe still clings to tribal

life and settlements, another section has adopted a caste name, abandoned its tribal language and functional independence, and have claimed caste status and has been recognized as such.



Many tribes, on the other hand, have refused contacts and have literally withdrawn themselves into their shells, as it were, with consequent distress and discomforts. They still afford field for anthropological research, though their exit is a matter of decades, if not years.

The exterior or scheduled castes who today have become pretty loud and vocal, who are being made politically conscious for their own interest or for that of others, have been mostly recruited from the tribal substratum, which fact has provided Ibbetson material for his highly interesting hypothesis of caste origins. In the Mirzapur district (U.P.), for example, a

number of primitive or quasi-aboriginal tribes have been included in the scheduled list as their social position is analogous to that of other depressed communities. The wandering tribes have spread far and wide, their ostensible means of livelihood, that of dancing, acrobatic feats and their skill in manufacture, more particularly in disposal of indigenous nostrums for the restoration of vigour and lost manhood, bring them in close contacts with rural and urban people and much of the dilution of blood of the latter is probably due to such contacts.

A glance at the tribal map of the United Provinces will show how the various tribal groups have distributed themselves. The main stream of tribal immigration is noticed in the Mirzapur district which geographically forms an adjunct to the table land of Chotanagpur and is surrounded by areas largely inhabited by tribal people. Plains are great levellers of cultures, and those of the tribes that have settled in the plains districts have either mixed with some other social groups at low levels of culture or have assimilated traits from the latter so much so that their identity today is difficult to ascertain. All the tribes except the nomadic, vagrant or criminal ones are therefore located in inaccessible hills and forests where for long they have been left more or less untouched by civilization.

We have in the United Provinces two areas of tribal concentration, one in the Mirzapur district, the other in the submontane tracts like Pilibhit, Gonda, Bareilly, Bahraich and Gorakhpur, also parts of the Kheri district. The Mirzapur tribes are racially akin to those living in the Chotanagpur plateau and there is a cultural similarity maintained by them which also indicates their common origin. The hill tribes inhabiting the cis-Himalayan region, popularly known as the Khasas or Khasiyas (not Khasis who inhabit Assam) may be identified with the earlier Indo Aryan tribes, those that moved into the hills and found 'secure asylum', where they have continued their peaceful cultural life for long undisturbed by events that so much complicated Indian history, ancient and medieval. The Tharus and Bhoksas, those that inhabit the submontane districts, have probably entered the Provinces from the north-east and are of mongoloid extraction as appears from their physical features though considerable intermixture has taken place among them in certain parts.

Besides these two tribal pockets—one in the north-east, the other in the south-east of the Province—large number of wandering and criminal tribes poured into the country and although their total strength is not more than two millions they are very widely distributed and every district in the Province has received some infiltration. These tribes appear to be of heterogeneous composition. At one end they represent a fair, dolichocephalic, leptorrhine element like the Sansiyas and Bhatus, at the other end they are represented by the Doms, a

dark-skinned, short-statured, flat-nosed people who 'scourge the eastern districts of the Province'. The Sansiyas, Bhatus and cognate tribes are found in the Central Provinces as well as in Central India and it is possible that their premigration home was outside the Province. They infiltrated into the United Provinces probably through Bundelkhand and Baghelkhand and Jhansi whence they spread far and wide into Agra and Oudh.

There are thus four important tribal groups in these Provinces: (1) the Mirzapur tribes, (2) the tribes of the submontane districts, (3) the Khasas and other tribes of the cis-Himalayan region, and (4) the wandering and vagrant tribes. The last one could be sub-divided into (*a*) nomadic and (*b*) settled. Most of these wandering tribes live by crime as their hereditary profession but there are also those like the Gujars or Ahirs who ply useful trade of tending cattle and supplying milk and milk products to markets and people among whom they live.

Blood Groups of the Tribal Population.

Under the auspics of the 1931 census operations an anthropological survey of the people of the United Provinces was undertaken by the author, and blood group investigations were combined with anthropometric measurements. Blood groups data from the Khasas of the cis-Himalayan region (*U.P. Historical Society's Journal*, Vol. XIII, Pt. 2, December 1940), the criminal tribes of the U.P., viz. the Karwals and Bhatus (*Science and Culture*, 1942, VII, No. 7) and the Doms (*Current Science*, 1942, No. 4), the Mongoloid Tharus of the Tarai districts (*J.R.A.S.B.*, 1942, *Science*) and some caste groups Kayasthas, Khattris and Chamars (*Science and Culture*, Vol. V, 1940) have already been published. Some of the samples so far recorded consisted of less than one hundred persons, and in order that the samples could be representative, further investigations were carried on among those groups. These and further data on the blood groups of tribes and castes of the Province are awaiting publication.

About 4,000 blood groups data have already been obtained by the author in the United Provinces alone, and if we add those that were reported by Malone and Lahiri for 'Hindus of the United Provinces (2,357)', the total number tested come to more than six thousand. The United Provinces thus lead other parts of India in blood group investigations and afford comparative material for testing the conclusions already arrived at by other investigators.

Blood Groups of the Korwas.

So far I have not presented any data on the blood groups of the Mirzapur tribes who are believed racially akin to the Munda

speaking tribes of Chotanagpur and adjacent Indian States. The Korwas are the most primitive element in the population of Mirzapur. They are found south of the river Son and along the frontier of Sarguja. In the district gazetteer of Palamau they are described as a jungle tribe numbering 7,000. They are numerous in the Banka Thana which lies on the border of Sarguja and also in Untary. There does not seem to be much racial difference between the Korwas of different parts, though the Sarguja Korwas are wilder than their brethren in adjacent districts of British India.

The Korwas of Dudhi are a dying group and hold their lives on slender terms. They have failed to adapt to new economic conditions and though they have taken to agriculture in recent times it does not provide them the security that is required for their survival. A sort of crude farming is practised by them, they scratch the rocky soil by means of miniature ploughs, sow all kinds of seeds together and offer prayers to the rain god and sacrifice fowls and pigeons to propitiate him. The Korwas are surrounded by a number of other tribes against whom they maintain strict endogamy and exclusiveness, both encouraging a sort of inbreeding, impairing their vitality and reducing them to social impotence. Local conditions instead of aiding the Korwas have aggravated their miserable plight. Water is scarce even for drinking purposes, for the rivers, though many in number, do not carry water throughout the year, and well-sinking is also difficult as the average depth of water is very great and before it can be met with granite rocks have to be pierced. The dry climate and scarcity of water have caused absence of bird life in the forests of Mirzapur.

The prospect of failure of crops and scarcity of fodder constantly dangles before their eyes and the Korwas and other tribal people in the area have developed an ingenious 'famine code', as it were, to cope with their food problem. Even in average years a substantial portion of their subsistence is made up of fruits and roots from the forest. Not all of these are edible ones, some are poisonous, but necessity is the mother of invention and the tribal people have succeeded in evolving an efficient technique of curing the poisonous fruits and roots out of which they make edible stuff. The roots and fruits are hunted out from the interior of forests, they are washed and cleaned, put in the sun and dried. When completely dry, they are ground into flour and cakes are prepared out of it. Often the flour is cooked with molasses or honey and a kind of *halua* is prepared which serves as a delicacy during festivals and as occasional treat to their friends and visitors.

As a tribe faced with extinction or absorption by more vital social groups, the Korwas are afraid of contacts, and they have developed a persecution complex which prevents free mixing with their neighbours. The Cheros, another tribal

group of pre-Dravidian affiliation are the reputed Baigas or medicinemen of the locality and they are supposed to wield great influence with evil spirits and disembodied souls whom they can use to nefarious ends. They are sorcerors, diviners and also adept in 'leechcraft'. The Korwas live in constant dread of them. The Cheros cause diseases and epidemics and know also how to get rid of them; they know spells and incantations which they cite for rousing their pet spirits to activity and for their effective mediation in human ills. The effect of this monopoly of 'spirit lore' by the Cheros has been the complete dependence of the various tribal groups on the Baigas, those versed in 'demonology'. Among the Cheros where this skill has been linked with a vague fear of the evil *Mana* of this weird class of artisans, a lot of taboos on food, marriage and social intercourse have imperceptibly established themselves which have succeeded in hedging in the Korwas and a few other tribal groups from culture contacts.

Where the self-sufficiency of primitive social groups is disturbed by new economic situation, social mobility, contacts and migration are indispensable for their survival. The Korwas have lost control of their environment, the security they had worked out by a careful combination of gleaning, hunting and agriculture has been invaded by more advanced groups and they are ill adapted to the environment today. They have withdrawn themselves into their shells as it were, and by so doing they have preserved their purity of blood but also are facing disorganization in their cultural life.

How far blood groups of the Korwas would affiliate or differentiate them from the cognate tribes of Munda ethnic stock, and how far they actually have kept aloof from their tribal neighbours will be an interesting inquiry. In a crowd of seven to eight hundred tribal people, I was asked by the local officials of the Sarguja State to spot out the Korwas and in 75% of the cases I was successful. Anyone who has lived long in the Ranchi district, I am sure, can tell a Munda from an Oraon though at first sight the difference is not palpable. The Korwas are a class by themselves, in physical features they are easily distinguished from the neighbouring tribes such as the Majhwars, the Kharwars, the Bhuiyas, the Cheros and the Oraons. The latter, most of them, are shorter in stature, less robust in constitution, a shade fairer in complexion and possess finer traits than the Korwas. The Majhwars, for example, have been Hinduized, have lived with Hindu castes, particularly the Koiri and the Tili who possess finer and more regular features, and with whom they have mixed in varying proportions. Culturally the Korwas have maintained their solidarity and have tabooed contacts, marriage and social intercourse with alien groups, and even with their neighbours, and whenever they come out in public, they gravitate and move in groups.

The Negroid Affiliation of the Korwas.

When I met the Korwas of Dudhi in 1931 I could not find any Negroid racial traits among them. The Korwas of Dudhi or of Palamau do not show connection with any Negroid race but two hill Korwa families of Sarguja were found to possess traits suggesting negroid affiliation. In the photograph of the Korwa families, printed along, the children show some negroid characters, particularly in the shape of the nose and in general contours.

The Korwas possess a very dark complexion. Sometimes it is soot black. They are usually tall with long forearms. They have a well-developed chest and their figure gives the idea of great power. The eyes are small and the lids swollen but no mongoloid fold or obliqueness is met among them. The nose is heavy, flat and depressed at the root. The lips are thick but not inverted. The jaws are heavy and prognathism is not uncommon. The hair is coarse, thick and very dark. It is either kept long, in which case it hangs unkempt over the shoulders, or, as the majority of the Korwas do today, the whole head is shaved with a tuft kept at the back; woolly hair is not found among them. Genuine Korwas have well-developed physique but they look famished and ill-clad.

The anthropometric data collected from Dudhi is given below: The average stature is 158·17 cm. and is higher than most of the other tribes in the locality except the Agarias who like the Asurs of Chotanagpur possess tall stature. The average cephalic index based on 109 individuals is 73·2 with a range from 67·3 to 81·6. The average cephalic index of the Mundas is 74·5, the Kharia 74·5 and the Korwas 74·4 recorded by Sir Herbert Risley. Surgeon Captain Drake-Brockman, who measured 25 Korwas of the U.P., found the average cephalic index to be 72·0 and the nasal index 75. The nasal index of the Korwas from my data was found to be 85·3 showing significant difference with that of Drake-Brockman. Different techniques may be responsible for such wide variation. My previous calculation on the basis of the data from 50 Korwas already published in (*Man in India*, Vol. IX, 1929) was, cephalic index 72·9 and nasal 83·7. A comparison of the means and standard deviations of my two samples do not reveal any significant differences. The majority of the Korwas are therefore dolichocephalic and platyrrhine.

An opportunity occurred in April 1941 to obtain blood groups of the Korwas of Dudhi, Sarguja and Palamau. In a fortnight's tour through the Korwa country posing as an itinerant medical practitioner dispensing homeopathic medicines which has stood me in good stead on so many occasions, I could collect 147 samples of blood from old people, women and children, the able-bodied adult is so difficult to secure during daytime. In the

summer holidays of 1941 I toured into the Korwa country, in the Sarguja State and collected further anthropometric data from the Korwas of the Sarguja State. In April 1942, I secured a large amount of data on the physical appearance and interrelations of the tribal groups in Dudhi, district Mirzapur. The complete analysis of the data will be presented later on in a suitable form. In this paper I would like to discuss the blood groups data from the Korwas.

TABLE 1.

Blood Groups of Korwas and Gene Frequencies.

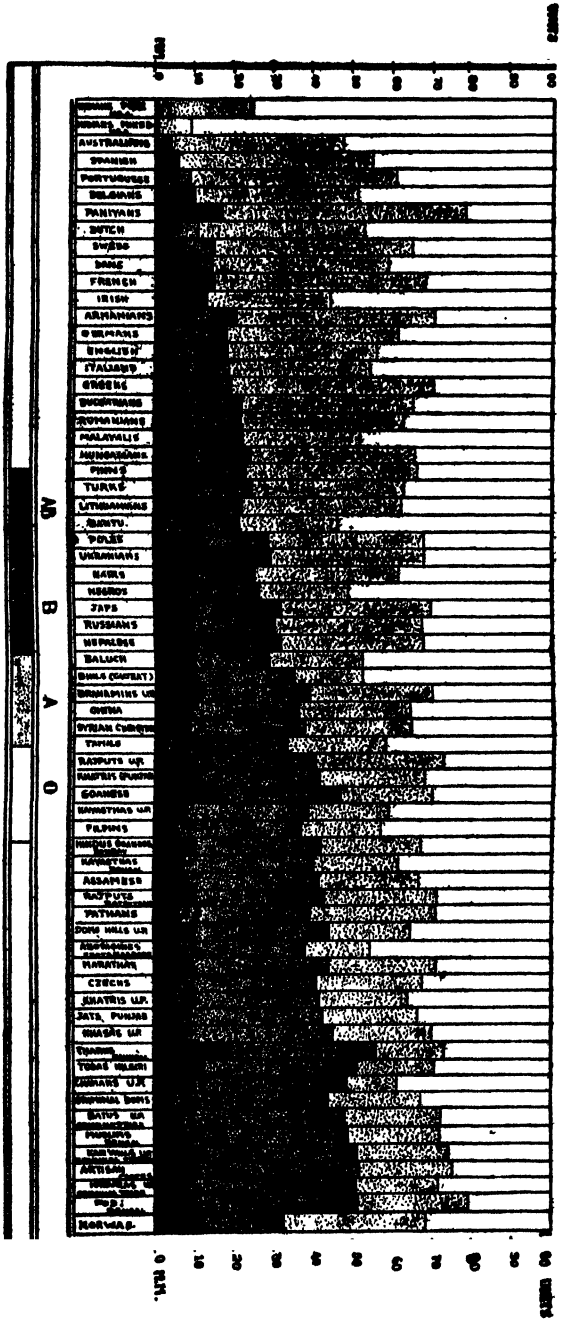
	O	A	B	AB	*p*	*q*	*r*
Korwas (Total 147) ..	31·7	35·6	20·4	12·3	·257	·159	·563
Korwas (89) ..	29·1	34·5	26·1	10·3	·258	·204	·539

Blood groups data from a number of tribes of pre-Dravidian affiliation have been published recently by Macfarlane and Sarkar. The latter took much pains to establish on the basis of blood groups data the ethnic difference between the Maler and the Oraons although the anthropometric data, definite or indefinite, do not warrant such an assumption. The following table gives the blood group percentages and gene frequencies of a number of tribes and castes of the United Provinces:—

TABLE 2.

	O	A	B	AB	*p*	*q*	*r*
U.P. Hindus (Malone and Lahiri) (2,357) ..	30·2	24·5	37·2	8·1	·190	·271	·549
U.P. Kayasthas (Majumdar) (110) ..	36·0	19·9	32·6	11·5	·148	·228	·600
U.P. Khattris (Majumdar) (126) ..	32·0	24·2	33·3	10·5	·185	·243	·565
U.P. Chamars (Majumdar) (151) ..	36·3	18·7	39·3	5·7	·139	·268	·602
U.P. Doms (Criminal) (Majumdar) (180) ..	32·8	22·8	39·4	4·4	·173	·278	·572
U.P. Doms (Hill) (Majumdar) (125) ..	36·0	20·0	33·8	10·2	·148	·235	·600
The Tharus (Majumdar) (241) ..	27·1	17·0	37·5	18·4	·144	·283	·520
The Bhatus (Criminal) (Majumdar) (113) ..	27·4	24·7	39·8	7·8	·198	·297	·523
The Karwals (Criminal) (Majumdar) (155) ..	25·8	22·6	40·6	10·9	·188	·306	·508
The Korwas (Majumdar) (147) ..	31·7	35·6	20·4	12·3	·257	·158	·563

From the data in Table 2 above, it appears that the Korwas have the highest A and the lowest B value of all the tribes and castes of these provinces. The criminal tribes and the Tharus all show high B percentage, even the high caste groups have high B blood among them. Malone and Lahiri found 37·2% B


AUSTRALIANS
SPANISH
PORTUGUESE
BELGIANS
PARSIANS
DUTCH
SWEDE
DANE
FRENCH
IRISH
ARMENIANS
GERMANS
ENGLISH
ITALIANS
GREEKS
NORWEGIANS
MALAYALIS
HUNGARIANS
FINNS
TURKS
LITHUANIANS
BANTU
POLES
UKRAINIANS
BAIRS
NEGROS
JAPS
RUSSIANS
NEPALESE
BALUCH
BRAHMINS UP
GHERIA
TAMILS
RAJPUTS UP
KAYETHS UP
GOANESE
KAYASTHAS UP
PILIPINS
KHATRIS UP
JATS, PUNJAB
AHIRS UP
PATHANS
DOMS MALS UP
MARATHAS
CHECHS
KHATRIS U.P.
JATS, PUNJAB
AHIRS UP
BANIS UP
KURMIS UP
MUSLIM
PASI
KORWAS
AVERAGE
0
100

among 2,357 Hindus, an apparently heterogeneous lot. No other tribe in the U.P. has shown such high A percentage as the Korwas. The following table gives blood groups of tribes with high A percentage:—

TABLE 3.

	O	A	B	AB	p	q	r
Paniyans (Aiyappan) (250) ..	20·0	62·4	7·6	10·6	·461	·078	·447
Chenchus (Macfarlane) (100) ..	37·0	37·0	18·0	8·0	·252	·133	·608
Mundas (Macfarlane) (120)	33·33	30·0	29·7	7·50	·219	·214	·577
Angami Nagas (Mitra) (105) ..	46·06	38·78	11·52	3·64	·242	·081	·680
Lushai (Mitra) (141) ..	32·63	44·68	16·31	6·38	·308	·128	·572
Konyaks (Br. Assoc.) (127) ..	45·7	40·2	10·2	3·9	·251	·072	·676
Korwas (Majumdar) (147)	31·7	35·6	20·4	12·3	·257	·158	·563

The data above show that A is considerably high among those tribes who are more or less isolates or have not been much disturbed by contacts. The Korwas of the U.P. are the most primitive element in the population of the Province, and the hill Korwas yet live in wild state in Sarguja forests and in Jashpur. The Konyaks, the Lushais, the Nagas, the Paniyans and the Chenchus all represent more or less inbred groups, and the Mundas of Chotanagpur inhabit a compact area and appear to have maintained their racial type. In all tribes the percentage of B is small and in some cases insignificant. As I have pointed out in a recent paper on the Bhils of Gujarat and their blood groups (*Current Science*, 1942, No. 9 and *Journal of the Gujarat Research Society*, Vol. 4, 1942) the standard size for blood group samples has to be determined before any valid conclusions about either the racial importance of blood groups or their genetic implications could be interpreted.

If we compare the tribal data in Table 3 with those from tribal groups elsewhere, we find similarity in percentage variation. Cleland and Burton (1929) found 56·2% A among the Australians and in (1930) the same authors found 58·4% A among them. Lee and Douglas found 60·3% A among 377 Australians investigated, while Tebutt and McConnel by investigating 1,176 cases found 36·9% A. In all these samples the percentage of B was very small. The Bantus of Africa have 19·2% B (Pyper, 1930), American Negroes 20 (Snyder), Solomon islands 16·8 (Howells, 1937), Samoa 13·7 (Nigg). Thus B is small or insignificant among very primitive tribes, and A is very high, in some cases 60% or more.

India has a high B concentration. A high percentage of B is found from India to Korea (Snyder). According to Hirzfelds (1918), the Hindus have 41·2% B. Malone and Lahiri found 37·2% B among the U.P. Hindus, Liu and Wang (1920) found

41·2% B among the North Chinese, Libman found 37·8% B among the Khirghiz, Melkich found 37·5% among the Buriats. In an earlier paper I have shown that the B incidence is most marked among those social groups which have passed from the tribal to caste status or those which are known to be hybrid castes. The depressed castes of Bengal show high B incidence, so do the criminal tribes of northern India. In other words, as soon as we include in our survey those tribes which are known to be mixed or those who from the nature of their occupation or otherwise allow inter-tribal marriages and extra-marital relationship with neighbouring tribes and castes, the percentage of B suddenly increases.

Whether India had any share in the dispersion of B, whether as it has been pointed out by some serologists, B has spread to Africa through Western Asia and eastward to Malaya Archipelago and further east, is too early to say. Howells (1933) thinks, B spread from central Asia and India through Indonesia to the Philippines along with Hindu influence as late as the first millennium A.D. and filtrated into Europe and still later with Oriental trade.

Dr. Gates has suggested that the A blood group arose through an O race of men in a particular locality developing the ability to produce the A mutation with a sufficient frequency for it to spread without the aid of selection. Regarding the priority of the origin of A, Gates argues that since various primitive and outlying peoples have A with little or no B, the A must have arisen much earlier in human evolution than B. The absence of B in Australia or its very small incidence is significant and Dr. Gates thinks that the B mutation has never appeared among them, and the very low percentage of B has probably been derived from crossing.

Two facts militate against the above hypothesis. In anthropoid apes which are the nearest kins of men, identical blood groups as in man occur. In the Gorilla and Chimpanzee only the A blood has been found and no B. Of 76 Chimpanzees tested, 71 were A and only 5 were O (Gates, *Sonderbidruck aus Zeitschrift für Rassen Kunde Jahrgang*, 1939, Band IX, Heft I). The Asiatic Orang-Utan showed 4 A, 5 B, and 2 AB out of 11 and of 10 Gibbons there were 2 A, 6 B and 2 AB. Thus the African anthropoids show all A with a sprinkling of O while their Asiatic colleagues show a high percentage of B. Orang (5+2) B and AB, Gibbon (6+2) B+AB. The lower monkeys, however, have not shown agglutinogens corresponding to the human agglutinogens A, B (Landsteiner and Miller). If the races have had different ancestry, the blood groups of the anthropoids could throw some light on the distribution or dispersion of the groups.

If the four blood groups all existed in man as is suggested by some scholars, the distribution of blood groups today may probably be explained by isolation and migration. Even if

there has been parallel mutations in man and apes, as suggested by Snyder, and which, we are told by Gates, is 'entirely in harmony with modern genetic conceptions', the rate of mutation is such that the incidence of the four groups in the population of the world is difficult to explain. It has been estimated, for example, that the rate at which mutations occur in the case of a character like blood group with no selective value, is insufficient to explain their maximum frequencies today. If A and B are mutations from O then, according to Wymen and Boyd, it would require 745,000 years for the genes A and B to attain their present frequencies. Gates has proved with the aid of Prof. Fisher that, if the mutation from O to A were 1 in 100,000 then without any intervention of selection, there would be 10% of A in the population after 250,000 years. The present frequencies would require so high a mutation rate that many consider it simply improbable. But Gates thinks there are periods during which particular mutations occur at a greatly increased rate, if so, then the mutation hypothesis receives additional arguments.

Macfarlane thinks that B has been in India for millennia and may have originated here in the ancestors of the lower castes of the north-east where the highest concentrations are found whence it has diffused into the higher castes. As the amount of O and B vary inversely, she thinks, that there may be genes for O in these low caste people with a relatively high mutation rate for B. Whether the centre of B mutation exists in the north-east or elsewhere, it is too early to say with any degree of probability. India has a population of 400 millions and 3 to 4 thousand blood groups tests are not adequate by themselves to explain the source of blood groups mutations or even the distribution of the genes. The Bhil data as I have pointed out elsewhere, will serve as a pointer.

Whenever two sections of the same people have been tested by the same author, one living isolated or inbred the other allowing intermixture, one living on the hill tops, the other in the plains district, divergent results have been noticed. The two Maler groups tested by Sarkar gave different A percentages, one group of 139 gave 15·83 A, another group of 235, 25·53. Two groups of Bhils were tested by Macfarlane in one (*n*. 44) 31·8% were O, 13·6 A, 52·3 B and 2·3 AB, in the other (*n*. 140) 18·6% were O, 23·6 A, 41·4 B and 16·4 AB. The Hill Doms of the U.P. showed 36·0% O, 20·9 A, 33·8 B and 10·2 AB, but the Doms of the plains, of the eastern districts, gave 32·8% O, 22·8 A, 39·4 B and 4·4 AB. The blood groups of the Korwas have shown a high percentage of A and a low percentage of B which distinguishes them from many of the tribes and castes we have tested, but line them up with many of the primitive tribal groups, whereas among the Paniyans we have the highest percentage of A, and the lowest B available in India. The results of blood group investigations have so far been extremely interesting and

significant, and we hope more workers will toe up with those in the field to map out the blood group distribution in India and the gene frequencies involved.

The testing sera were made at Lucknow by Dr. V. S. Manglik of the King George Medical College and the potency calculated by titration. I am thankful to Dr. Manglik for his ungrudging help. I am also grateful to the Imperial Serologist, Calcutta, for supplying me with testing sera which supplemented my stock and also helped me to check the potency of those made at Lucknow. The control was provided by my own blood which is B and that of my peon which is O. The blood was collected from the forefinger of the left hand by pricking with an automatic needle calibrated according to requirements. The usual precautions were taken to make the results free from prejudice.

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